APPENDIX II

EFFLUENT AND WATER CHEMISTRY REPORT

EFFLUENT AND WATER CHEMISTRY REPORT IN SUPPORT OF THE 2020 AEMP ANNUAL REPORT FOR THE DIAVIK DIAMOND MINE, NORTHWEST TERRITORIES

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March 2021
20136424/10000

Doc No. RPT-2040 Ver. 0
PO No. 3104360642

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Executive Summary

In 2020, Diavik Diamond Mines (2012) Inc. completed the field component of its Aquatic Effects Monitoring Program (AEMP) in Lac de Gras, Northwest Territories, as required by Water Licence W2015L2-0001, according to the *AEMP Design Plan Version 4.1* approved by the Wek'èezhìı Land and Water Board. This report presents the analyses of effluent and water chemistry data collected during the 2020 AEMP field sampling, and from relevant stations in the Surveillance Network Program. The objective of the water quality monitoring component of the AEMP was to assess effects of the Diavik Diamond Mine (Mine) on water quality in Lac de Gras. Initial data analyses were completed to identify substances of interest (SOIs), which are a subset of variables with potential Mine-related effects.

Concentrations of regulated effluent variables were below applicable Water Licence effluent quality criteria in the 2020 monitoring period, and effluent toxicity testing indicated that the effluent was not toxic to aquatic life. Nearly all concentrations measured in samples collected at the mixing zone boundary were within the relevant AEMP water quality Effects Benchmarks for the protection of aquatic life and drinking water. No additional variables were added to the SOI list in 2020 based on the effluent and mixing zone screening results.

During the ice-cover season, elevated conductivity was measured in the bottom two-thirds of the water column in the near-field (NF) area, indicating the depth range where the effluent plume was located. Dissolved oxygen (DO) concentrations (usually greatest just below the ice and declining slightly with increasing depth) and pH values were typically uniform throughout the water column or decreased slightly with depth. Water temperature increased gradually with depth at most stations and turbidity was typically uniform throughout the water column. During the open-water season, in situ water quality measurements for conductivity, DO, water temperature, pH, and turbidity profiles were typically uniform throughout the water column.

At AEMP sampling stations, two total manganese samples collected during the ice-cover season exceeded the AEMP drinking water Effects Benchmark. In addition, one dissolved manganese sample collected in the ice-cover season and five dissolved zinc samples collected in the open-water season were above the AEMP aquatic life Effects Benchmarks. Laboratory pH values were below the Effects Benchmark in many samples; however, these occurrences were likely natural and unrelated to the Mine discharge. Concentrations of all variables in all other samples collected during the 2020 AEMP were below the relevant Effects Benchmarks for the protection of aquatic life and drinking water.

Water quality variables analyzed in 2020 were initially evaluated for inclusion as SOIs against four criteria. Twenty-eight variables met the criteria for inclusion as SOIs in 2020. No variables were added to the SOI list in 2020 based on the effluent or mixing zone screening results (Criterion 1 and 2).

Water quality variables were assessed for a Mine-related effect in Lac de Gras according to Action Levels in the Response Framework. There are nine Action Levels defined in the Response Framework for water chemistry. Twenty-one variables demonstrated an effect equivalent to Action Level 1 and included total dissolved solids (TDS), total suspended solids (TSS), turbidity (lab), calcium, chloride, magnesium, potassium, sodium, sulphate, ammonia, nitrate, aluminum, antimony, barium, chromium, copper, molybdenum, silicon, strontium, sulphur, and uranium. With NF area median concentrations greater than two times the median concentrations in the reference dataset, these variables were identified as SOIs (Criterion 3).

Of the 21 SOIs that triggered Action Level 1, eight also triggered Action Level 2 and included TDS, chloride, sodium, sulphate, nitrate, molybdenum, strontium, and uranium. These variables had 5th percentile concentrations in the NF area that were greater than two times the median concentration in the reference dataset and were greater than the normal range for Lac de Gras. None of the SOIs triggered Action Level 3.

Spatial trends of decreasing concentrations with distance from the Mine effluent discharge were evident for most of the 21 SOIs that triggered Action Levels 1 or 2 in 2020 based on a graphical and statistical evaluation of the data. An exception was TSS, which had concentrations in the mid-field (MF) area similar to those measured in the NF area in both seasons. The results of these analyses provided confirmation that the increases observed in the NF area for these variables were related to the Mine effluent discharge.

Water quality variables were assessed for effects at stations potentially affected by Mine-related dust emissions. Twenty-five variables had concentrations greater than two times the median of the reference dataset at one or more of the four MF area stations located within the estimated zone of influence (ZOI) from dust deposition from the Mine; these variables were identified as SOIs (Criterion 4). Of these 25 SOIs, 18 also triggered Action Level 1 in the NF area, indicating that the exceedances at the MF stations were at least partly caused by dispersion of Mine effluent into the lake. The remaining seven variables (i.e., boron, cobalt, iron, lead, thallium, tin, and zinc) did not trigger Action Level 1 in the NF area and had median concentrations at one or more of the four MF stations that were elevated compared to the median of the NF area concentrations. While there is some potential that these elevated values may be related to dust deposition, this interpretation is not supported by the absence of similar increases at the other stations within the ZOI; in addition, spatial trends within the ZOI were consistent with effects originating from the Mine effluent. Overall, analysis of the water quality results in 2020 provided no evidence to suggest that Mine-related dust is affecting the water quality of Lac de Gras. Although dust deposition has the potential to contribute to effects on water quality during certain times of the year (e.g., ice break-up, extreme wind events), several lines of evidence suggest that isolating the specific effects from dust emissions on water quality in Lac de Gras from other mine sources (e.g., effluent) is not possible or necessary to manage Mine-related effects in Lac de Gras.

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Acronyms and Abbreviations

AEMP	Aquatic Effects Monitoring Program
AIC	Akaike's information criterion
AICc	Akaike's information criterion, corrected for small sample size
AL	Action Level
ALS	ALS Laboratories
BV Labs	Bureau Veritas Laboratories, formerly Maxxam Analytics
$CaCO_3$	calcium carbonate
CALA	Canadian Association of Laboratory Accreditation
CFU	colony forming unit
CWQGs	Canadian Water Quality Guidelines
DDMI	Diavik Diamond Mines (2012) Inc.
DL	detection limit
DO	dissolved oxygen
DOC	dissolved organic carbon
DQO	data quality objective
EA	Environmental Assessment
e.g.	for example
et al.	and more than one additional author
EQC	effluent quality criteria
FF	far-field
Golder	Golder Associates Ltd.
IC	ice-cover
i.e.	that is
LDG	Lac de Gras
LDS	Lac du Sauvage
MF	mid-field
Mine	Diavik Diamond Mine
Mine centroid	geographic centre of the Mine
MZ	mixing zone
NF	near-field
NIWTP	North Inlet Water Treatment Plant
OW	open-water
P	probability
QA/QC	quality assurance/quality control
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
r^2 or R^2	coefficient of determination
RPD	relative percent difference

SD	standard deviation
SES	special effects study
SNP	Surveillance Network Program
SOI	substance of interest
SOP	Standard Operating Procedure
TDS	total dissolved solids
TSS	total suspended solids
WLWB	Wek'èezhìı Land and Water Board
ZOI	zone of influence

Symbols and Units of Measure

%	percent
>	greater than
<	less than
×	times
μg/L	micrograms per litre
μg-N/L	micrograms nitrogen per litre
μg-P/L	micrograms phosphorus per litre
μS/cm	microsiemens per centimetre
km	kilometre
km^2	square kilometre
m	metre
mg/L	milligrams per litre
mL	millilitre
NTU	nephelometric turbidity unit

1 INTRODUCTION

1.1 Background

In 2020, Diavik Diamond Mines (2012) Inc. (DDMI) completed the field component of its Aquatic Effects Monitoring Program (AEMP) for the Diavik Diamond Mine (Mine), as required by Water Licence W2015L2-0001 (WLWB 2015). This report presents the analysis of effluent and water chemistry data collected during the 2020 sampling year, which was carried out by Golder Associates Ltd. (Golder) according to the *AEMP Design Plan Version 4.1* (Golder 2017a).

AEMP Design Plan Version 4.1 (Golder 2017a) is the currently approved version of the AEMP design; however, a number of changes outlined in the proposed *AEMP Design Plan Version 5.2* (Golder 2020a) were approved through the Wek'èezhìı Land and Water Board (WLWB) directives (i.e., 25 March 2019, 21 October 2019, and 1 June 2020 Decision Packages related to the *2014 to 2016 Aquatic Effects Re-evaluation Report* and *AEMP Design Plan Version 5.0*, *2017 AEMP Annual Report*, *2018 AEMP Annual Report*, and *AEMP Design Plan Version 5.1*); these items have been incorporated into the 2020 AEMP Annual Report, where relevant.

While the Mine effluent discharge is the main source of constituents to Lac de Gras and the most likely factor responsible for effects in the receiving environment, the potential influence of other Mine sources (e.g., dust deposition) on water quality in Lac de Gras are also considered herein. Water chemistry data for the Mine effluent and mixing zone boundary in Lac de Gras were obtained from the Surveillance Network Program (SNP) for the Mine, while water quality data in Lac de Gras were collected as part of AEMP field programs, which were carried out by DDMI staff according to the *AEMP Design Plan Version 4.1* (Golder 2017a) and the associated *Quality Assurance Project Plan Version 3.1* (QAPP; Golder 2017b).

1.2 Objectives

The overall objective of the water quality monitoring component of the AEMP is to assess the effects of the Mine on water quality in Lac de Gras. Water chemistry data were analyzed to determine whether there were differences in water quality between areas exposed to Mine-related inputs and reference conditions for Lac de Gras (as defined in the *AEMP Reference Conditions Report Version 1.4* [Golder 2019a]) and to evaluate spatial trends in water quality in Lac de Gras.

1.3 Scope and Approach

The 2020 AEMP water quality survey in Lac de Gras was carried out according to the requirements specified in the *AEMP Design Plan Version 4.1* for an interim monitoring year (Golder 2017a). In an interim year the effects on water quality in Lac de Gras are assessed by evaluating whether an Action Level has been triggered, and spatial analysis of effects are assessed by evaluating trends in water quality variables in relation to the diffusers in Lac de Gras. Summaries of the chemistry of Mine effluent and lake water at the mixing zone boundary in Lac de Gras have also been provided, including an evaluation of seasonal variation. An assessment of trends over time has been provided in previous Aquatic Effects Re-evaluation Reports (e.g., Golder 2019b, 2020b) rather than in annual reports.

Water quality variables were assessed for a Mine-related effect using gradient analysis and according to Action Levels described in the *AEMP Design Plan Version 4.1* (Golder 2017a). The magnitude, extent, and importance of effects have been defined in the Action Level criteria. Field measurements (i.e., depth profile data) have been discussed qualitatively herein, and nutrients (i.e., phosphorus and nitrogen) have been evaluated in the *Eutrophication Indicators Report* (Appendix XIII).

The results of the water quality Action Level screening were used in combination with an assessment of effluent and mixing zone chemistry, and potential effects from dust deposition from the Mine, to identify a subset of variables with potential Mine-related effects, referred to as substances of interest (SOIs). The intent of defining SOIs was to identify a meaningful set of variables for further analyses, while limiting analyses for variables that were less likely to be affected by the Mine.

Water quality variables were assessed for the presence of spatial trends with distance from the Mine-effluent diffusers in Lac de Gras, and in relation to stations located within the estimated zone of influence (ZOI) from dust deposition. Gradient analysis in the form of linear regressions along the three mid-field (MF) transects were completed for SOIs that triggered Action Levels. Finally, SOIs were evaluated for seasonal trends in the Mine effluent and at the mixing zone boundary in Lac de Gras.

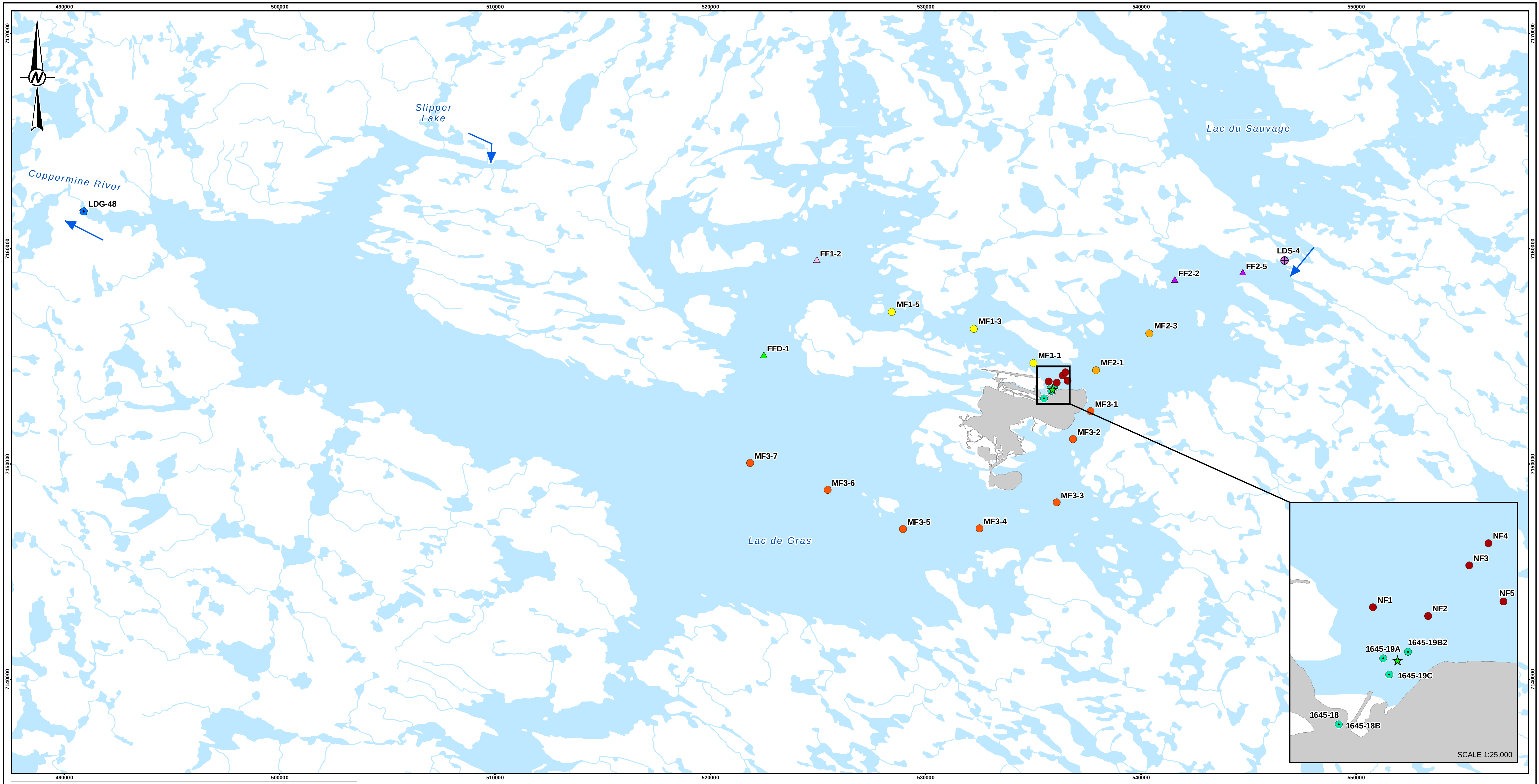
2 METHODS

2.1 Field Sampling

The 2020 water quality field sampling program included in situ water quality measurements and collection of water samples for chemical analysis. The in situ water column profile measurements were taken at AEMP stations using a multi-parameter water quality meter (YSI) following the methods described in DDMI's Standard Operating Procedure (SOP) ENVI-684-0317 "SOP YSI ProDSS". Collection of water samples followed the protocols described in ENVI-923-0119 "AEMP SOP Combined Open Water and Ice Cover". Water samples were handled according to ENVI-902-0119 "SOP Quality Assurance Quality Control" and ENVI-900-0119 "SOP Chain of Custody".

Effluent and water quality data collected in support of the Mine's SNP were incorporated herein. Data were summarized for the period of effluent discharge from 1 November 2019 to 31 October 2020. Treated effluent from the North Inlet Water Treatment Plant (NIWTP) was sampled from both diffusers; SNP 1645-18 is the original diffuser station in Lac de Gras, and SNP 1645-18B is the second diffuser station, which became operational in September 2009 (Figure 2-1). Both diffusers discharged continuously to Lac de Gras throughout the 2020 monitoring period. Sampling was completed every six days at each discharge point.

Water quality sampling at the mixing zone boundary was completed monthly at three stations (i.e., SNP 1645-19A, SNP 1645-19B2, SNP 1645-19C), which are located along a semi-circle, approximately 60 m from the effluent diffusers (Figure 2-1). These stations represent the edge of the mixing zone, which covers an area of approximately 0.01 km^2. Sampling at the mixing zone boundary occurred monthly at the water surface (2 m depth) and at 5 m depth intervals (5, 10, 15, and 20 m depth) at each station for the duration of the 2020 monitoring period. Sampling did not occur during the month of June 2020 due to unsafe ice conditions.



LEGEND

★ DIFFUSERS

⊙ SURVEILLANCE NETWORK PROGRAM

STATION LOCATIONS

△ FAR-FIELD 1

▲ FAR-FIELD 2

▲ FAR-FIELD D

⬟ LAC DE GRAS OUTLET

⊕ LAC DU SAUVAGE OUTLET

● MID-FIELD 1

● MID-FIELD 2

● MID-FIELD 3

● NEAR-FIELD

→ FLOW DIRECTION

— WATERCOURSE

▨ DIAVIK FOOTPRINT

▨ WATERBODY

0 5 10

1:175,000 KILOMETRES

REFERENCE(S)
HYDROGRAPHY DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
PROJECTION: UTM ZONE 12 DATUM: NAD 83

CLIENT
RioTinto

PROJECT
DIAVIK DIAMOND MINES (2012) INC.

CONSULTANT
GOLDER

YYYY-MM-DD	2021-03-22
DESIGNED	MC
PREPARED	LMS
REVIEWED	MC
APPROVED	RLS

TITLE
LOCATIONS OF RELEVANT SNP AND AEMP WATER QUALITY SAMPLING STATIONS, 2020

PROJECT NO.	PHASE	REV.	FIGURE
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Water quality sampling at AEMP stations in 2020 was carried out according to the sampling design for an interim year AEMP, which includes sampling in the NF and MF areas of the lake (Golder 2017a). The far-field (FF) areas in Lac de Gras are sampled every third year during the comprehensive monitoring program to allow for detailed assessment of Mine-related effects. The next comprehensive monitoring program is scheduled for 2022. Per the WLWB directives approving a number of updates outlined in the proposed *AEMP Design Plan Version 5.2* (Golder 2020a), FF1-2 will be sampled during interim monitoring years, instead of only being sampled in comprehensive years, and a new station, FFD-1, will also be sampled annually. These additional stations will allow for assessing effects beyond the MF1 area, in the FF1 area (as represented by FF1-2) and in the northern channel, east of the East Island, which could not previously be assessed during interim monitoring years. These updates were included in the 2020 monitoring program.

In total, water quality samples were collected at 23 stations in 2020 (Figure 2-1). Sampling occurred at a cluster of five replicate stations in the NF area (i.e., NF1 to NF5), three MF areas (i.e., MF1, MF2, and MF3), and two FF stations (i.e., FF1-2 and FFD-1). Three stations were located in the MF1 area (i.e., MF1-1, MF1-3, MF1-5), four stations in the MF2 area (i.e., MF2-1, MF2-3, FF2-2, FF2-5), and seven stations in the larger MF3 area (i.e., MF3-1 to MF3-7). The NF, MF, and FF stations were approximately 20 m deep. Single stations were sampled at each of the Lac de Gras outflow to the Coppermine River (LDG-48) and the Lac du Sauvage outflow to Lac de Gras (LDS-4). Coordinates of the AEMP stations, and their approximate distance from the Mine effluent diffusers along the most direct flow path are provided in Table 2-1.

Sampling stations in the MF areas are arranged along transects that run from the NF area towards the FF areas (i.e., FF1, FFA, and FFB; the latter two FF areas and four of the five FF1 stations are not sampled in interim years and, therefore, are not shown on Figure 2-1). The MF1 transect is located northwest of the NF area and runs towards the FF1 area. The new station between the FF1 and MF3 areas (FFD-1) provides data to assess the spatial extent of effects extending from the existing MF1/FF1 areas into the northern channel area of Lac de Gras, east of the East Island. Therefore, FFD-1 will form a part of the existing MF1 transect. The MF2 transect is located to the northeast and includes the FF2 stations near the Lac du Sauvage (LDS) inlet. The MF3 transect is located south of the NF area, and runs towards the FFB and FFA areas.

The 2020 AEMP water quality sampling occurred over two monitoring seasons: ice-cover and open-water. Ice-cover season (i.e., late winter) sampling occurred from 20 April to 1 May 2020. Open-water sampling occurred from 16 August to 7 September 2020. The same locations were sampled in each season, with the exception of LDS-4, which was sampled in the open-water season only. A detailed sampling schedule for the 2020 AEMP is provided in Attachment A, Table A-1.

Stations in the NF and MF areas were sampled at three depths (i.e., top, middle, and bottom) during each season, as these stations were likely to have vertical gradients in water quality due to the Mine discharge. Near-surface water samples (top) were collected at a depth of 2 m below the water surface, and bottom samples were collected at a depth of 2 m above the lake bottom. Mid-depth samples were collected from the mid-point of the total water column depth. Stations FF1-2, FFD-1, LDG-48, and LDS-4 were sampled at mid-depth only.

2.2 Laboratory Analysis

Water samples were shipped to Bureau Veritas Laboratories (BV Labs; formerly Maxxam Analytics Inc.) in Calgary, Alberta (AB), or Edmonton, AB, Canada for analysis of general parameters, major ions, nutrients and total metals[1]. In 2020, water samples were analyzed for ammonia by both BV Labs in Calgary or Edmonton, and ALS Laboratories (ALS) in Vancouver, BC, Canada. A list of the variables analyzed by BV Labs in 2020 is provided in Table 2-2.

Laboratory detection limits (DLs) represent the lowest concentration of a substance that can be reliably measured by the analytical laboratory. The target DLs for the AEMP are defined in the *AEMP Design Plan Version 4.1* (Golder 2017a) and are summarized in Table 2-2. Deviations from the target DLs and potential effects on data quality are discussed in Attachment B.

Table 2-1 Locations of the 2020 AEMP Water Quality Monitoring Stations

Area	Station	UTM Coordinates		Distance from Diffusers[(a)] (m)
		Easting	Northing	
NF	NF1	535740	7153854	394
	NF2	536095	7153784	501
	NF3	536369	7154092	936
	NF4	536512	7154240	1,131
	NF5	536600	7153864	968
MF1	MF1-1	535008	7154699	1,452
	MF1-3	532236	7156276	4,650
	MF1-5	528432	7157066	8,535
MF2	MF2-1	538033	7154371	2,363
	MF2-3	540365	7156045	5,386
FF2	FF2-2	541588	7158561	8,276
	FF2-5	544724	7158879	11,444
MF3	MF3-1	537645	7152432	2,730
	MF3-2	536816	7151126	4,215
	MF3-3	536094	7148215	7,245
	MF3-4	532545	7147011	11,023
	MF3-5	528956	7146972	14,578
	MF3-6	525427	7148765	18,532
	MF3-7	521859	7150039	22,330
FF1	FF1-2	524932	7159476	12,915
-[(c)]	FFD-1	522495	7155084	17,315
Outlet of Lac de Gras	LDG-48	490900	7161750	55,556
Outlet of Lac du Sauvage	LDS-4	547191	7160256	(b)

a) Approximate distance from the Mine effluent diffusers along the most direct path of effluent flow.

b) Distance not shown as the station is located upstream of Lac de Gras.

c) Stations designated FFD do not represent a distinct FF sampling area.

UTM = Universal Transverse Mercator, NAD83, Zone 12V; NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage.

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[1] The term metal is used throughout this report and includes non-metals (i.e., selenium) and metalloids (i.e., arsenic).

Table 2-2 Detection Limits for Water Quality Analysis, 2020

Variable	Unit	Detection Limit[(a)]
Conventional Parameters		
Total alkalinity as $CaCO_3$	mg/L	0.5
Specific conductivity – lab	µS/cm	1
Total hardness as $CaCO_3$	mg/L	0.5
pH – lab	pH units	-
Total dissolved solids, calculated	mg/L	-
Total dissolved solids, measured	mg/L	1
Total suspended solids	mg/L	1
Total organic carbon	mg/L	0.2
Turbidity – lab	NTU	0.1
Major Ions		
Bicarbonate	mg/L	0.5
Calcium (dissolved)	mg/L	0.01
Carbonate	mg/L	0.5
Chloride	mg/L	0.5
Fluoride	mg/L	0.01
Hydroxide	mg/L	0.5
Magnesium (dissolved)	mg/L	0.005
Potassium (dissolved)	mg/L	0.01
Sodium (dissolved)	mg/L	0.01
Sulphate	mg/L	0.5/0.05[(b)]
Nutrients		
Ammonia	µg-N/L	5
Nitrate	µg-N/L	2
Nitrite	µg-N/L	1
Nitrate + nitrite	µg-N/L	2
Total Kjeldahl nitrogen	µg-N/L	20
Total dissolved nitrogen	µg-N/L	20
Total nitrogen	µg-N/L	20
Soluble reactive phosphorus	µg-P/L	1
Total dissolved phosphorus	µg-P/L	2
Total phosphorus	µg-P/L	2
Total Metals		
Aluminum	µg/L	0.2
Antimony	µg/L	0.02
Arsenic	µg/L	0.02
Barium	µg/L	0.02
Beryllium	µg/L	0.01
Bismuth	µg/L	0.005
Boron	µg/L	5
Cadmium	µg/L	0.005
Calcium	mg/L	0.01
Chromium	µg/L	0.05
Cobalt	µg/L	0.005
Copper	µg/L	0.05
Iron	µg/L	1
Lead	µg/L	0.005
Lithium	µg/L	0.5
Magnesium	mg/L	0.005
Manganese	µg/L	0.05
Mercury	µg/L	0.002
Molybdenum	µg/L	0.05
Nickel	µg/L	0.02
Potassium	mg/L	0.01
Selenium	µg/L	0.04
Silicon	µg/L	50
Silver	µg/L	0.005
Sodium	mg/L	0.01
Strontium	µg/L	0.05
Sulphur	mg/L	0.5/0.1[(b)]
Thallium	µg/L	0.002
Tin	µg/L	0.01
Titanium	µg/L	0.5
Uranium	µg/L	0.002
Vanadium	µg/L	0.05
Zinc	µg/L	0.1
Zirconium	µg/L	0.05

a) Detection limits for a subset of samples (n = 80; 0.6%) were raised in 2020; details and a discussion of potential effects on data quality are provided in Attachment B.

b) Samples for sulphate and sulphur were analyzed using either inductively coupled plasma-mass spectrometry (ICP-MS) or inductively coupled plasma optical emission spectrometry (ICP-OES). Samples with reported concentrations that were less than the DL for the ICP-MS method (0.5 mg/L) were analyzed using ICP-OES at a lower DL (0.1 mg/L), to improve the sensitivity of the reported results. A discussion of potential effects on data quality is provided in Attachment B.

µS/cm = microsiemens per centimetre; NTU = nephelometric turbidity unit; µg-N/L = micrograms nitrogen per litre; µg-P/L = micrograms phosphorus per litre; $CaCO_3$ = calcium carbonate.

2.3 Quality Assurance/Quality Control

The *Quality Assurance Project Plan Version 3.1* (Golder 2017b) outlines the quality assurance (QA) and quality control (QC) procedures employed to support the collection of scientifically defensible and relevant data addressing the objectives of the AEMP. A description of QA/QC practices applied to the water quality component of the 2020 AEMP and an evaluation of the QC data are provided in Attachment B. A summary of the main QC issues identified during the 2020 AEMP sampling is provided herein. With the exception of the specific circumstances summarized below and in Attachment B, data collected during the 2020 AEMP were considered to be of acceptable quality.

2.3.1 Ammonia Investigation

In 2020, DDMI sent lake water quality samples to both BV Labs and ALS for analysis of ammonia. The reader is also directed to Appendix 4B of the *2014 to 2016 Aquatic Effects Re-evaluation Report Version 1.1* (Golder 2019b) and Appendix B of the 2017, 2018, and 2019 AEMP annual effluent and water chemistry reports (Golder 2018, 2019c, 2020c) for a review of the history of the data quality issues identified for ammonia and a description of recent investigations and follow-up studies.

BV Labs completed a review of the ice-cover season ammonia data reported by both laboratories and found that the BV Labs data were affected by sample contamination, whereas the ALS data had fewer data quality issues. Therefore, the ALS ice-cover dataset were used in the data analyses. During the ice-cover season, sample bottles from both laboratories were pre-charged with sulphuric acid as preservative.

Contamination of ammonia samples caused by preservatives has been observed in previous sampling rounds; therefore, ammonia samples for the 2020 open-water season were submitted unpreserved to BV Labs. After arriving at the laboratory, samples were preserved under controlled conditions. An inter-laboratory comparison study of the open-water data conducted by BV Labs determined that both open-water datasets contained several unusually high values; however, the ALS open-water data were recommended for reporting. This recommendation was implemented in the AEMP data analyses.

Further details on efforts to improve ammonia data quality in 2020 are provided in Attachment B, including results of the 2020 inter-laboratory comparison studies. Although there were data quality issues for ammonia in 2020, these issues have not compromised the ability to detect Mine-related effects on ammonia that would result in adverse effects on aquatic life. Data quality issues are related to detecting ammonia at low concentrations, near the DL (5 µg-N/L), within the range of 5 to 50 µg-N/L. These low concentrations are at the absolute limit of instrument sensitivity and, as a result, are subject to high uncertainty. The AEMP Effects Benchmark for ammonia is 4,730 µg-N/L, and the lowest Action Level criterion based on the Effects Benchmark (i.e., Action Level 3: top of normal range plus 25% of Effects Benchmark) is 1,186 µg-N/L, which is well above the range where QC issues related to the low DL have been encountered. DDMI will continue to work with the analytical laboratory to determine a path forward for ammonia analysis for future monitoring.

2.3.2 Abnormal Results for Dissolved Metals

In 2020, abnormal results were identified in open-water AEMP samples analyzed for dissolved metals. Initial graphical evaluation of the data reported by BV Labs suggested potential sample contamination; eight dissolved metals samples had elevated concentrations compared to the total concentrations (>30%) and compared to values at other nearby stations (Figure B-2 in Attachment B).

Dissolved metals used in the AEMP data analyses are limited to the major ions (calcium, magnesium, potassium, and sodium). Due to the identified sample contamination; the AEMP figures and analyses were presented for the total forms in both seasons. Dissolved calcium, magnesium, potassium, and sodium are also used in the calculation of TDS. Therefore, the potential contamination affecting dissolved metals during the open-water season also affected calculated TDS. Values of TDS were recalculated for the eight affected samples using the total concentrations. These adjusted TDS values were used in the data analyses.

2.4 Data Analysis

2.4.1 Overview and Substances of Interest

Initial data analyses were completed to identify SOIs (i.e., a subset of variables with the potential to show Mine-related effects). The criteria used to select SOIs are defined in the *AEMP Design Plan Version 4.1* (Golder 2017a) and are summarized as follows:

- *Criterion 1:* effluent chemistry data collected at SNP 1645-18 and SNP 1645-18B were compared to effluent quality criteria (EQC) defined in the Water Licence (Sections 2.4.4.2 and 3.2.4). Variables with concentrations in individual grab samples greater than EQC for the Maximum Average Concentration (Table 2-4) were included as SOIs.
- *Criterion 2:* variables with concentrations at the mixing zone boundary (i.e., SNP 1645-19A, SNP 1645-19B2, SNP 1645-19C) that exceeded AEMP Effects Benchmarks (Table 2-5; Sections 2.4.4.3 and 3.2.5) were included in the SOI list, provided there was not a large percentage of values below the DL (i.e., greater than 90%).
- *Criterion 3:* water quality variables were assessed according to Action Levels in the Response Framework (Sections 2.4.5.1 and 3.4). Variables that triggered Action Level 1 in the NF area were added to the SOI list. Action Level 1 is triggered if the median of the NF area is greater than two times the median of the reference dataset, together with strong evidence of a link to the Mine.
- *Criterion 4:* variables that triggered an effect equivalent to Action Level 1 at individual MF area stations that fall within the ZOI from dust deposition in Lac de Gras (i.e., between 0.3 and 4.2 km from the boundary of the Mine footprint (Golder 2020b): MF1-1, MF3-1, MF3-2, and MF3-3) were added to the SOI list (Sections 2.4.5.4 and 3.7).

Water quality variables analyzed in 2020 (Table 2-2) were initially evaluated for inclusion as SOIs against the above noted four criteria, with the exception of the following analytes or variables:

- dissolved oxygen (DO), temperature, pH, and specific conductivity (i.e., variables associated with in situ water column profile measurements) which are assessed in Section 3.3
- carbonate and hydroxide, which are not detected at the pH range encountered in Lac de Gras
- bicarbonate, which is redundant with total alkalinity and not a parameter of toxicological concern
- hardness, which is integrated into the calculation of Effects Benchmarks for certain parameters (e.g., copper, lead, nickel), but is not a parameter of toxicological concern itself

- nutrients that are generally not toxic to aquatic organisms (i.e., phosphorus and some forms of nitrogen), which are evaluated in the *Eutrophication Indicators Report* (Appendix XIII)
- nitrate + nitrite, which was evaluated separately as nitrate and nitrite
- dissolved metals; metals were evaluated in terms of the total concentrations[2], which have AEMP Effects Benchmarks (Section 2.4.4.3) and defined reference conditions for Lac de Gras (as described in the *AEMP Reference Conditions Report Version 1.4* [Golder 2019a])

Data for nitrogen parameters that may be toxic to aquatic organisms at elevated concentrations were summarized herein (i.e., ammonia, nitrate, and nitrite) and in the *Eutrophication Indicators Report* (Appendix XIII), because they also have the potential to result in nutrient enrichment.

Variables that triggered Action Level 1 were retained as SOIs (Section 3.5.1). In 2020, total and dissolved calcium, magnesium, potassium, and sodium in the NF area triggered Action Level 1. In previous years when both the dissolved and total fractions triggered Action Level 1, graphing and statistical analyses were conducted on the dissolved fractions only, to avoid redundancy. However, review of the analytical data in 2020 indicated that some major ions and dissolved metals AEMP samples from the open-water season were potentially contaminated (Section 2.3.2; Attachment B); therefore, analyses were presented for the total fractions instead. In addition, while both total dissolved solids (TDS; calculated) and TDS (measured) triggered Action Level 1, to avoid redundancy, the analysis was focused on TDS (calculated).

Analyses completed on SOIs that met one or more of the criteria listed above, along with references to the location where the methods and results for each analysis can be found in the report, are summarized in Table 2-3.

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[2] Three metals have AEMP Effects Benchmarks for the dissolved concentrations (i.e., aluminum, manganese, and zinc). The dissolved metal concentrations for these three metals were used in the Effects Benchmark comparison. If one of these variables met Criterion 2 the total concentration would be added to the SOI list to avoid redundancy.

Table 2-3 Data Analyses Completed on Substances of Interest

Analysis	SOIs	Location in Report
An examination of loads in Mine effluent and effluent chemistry (from SNP 1645-18 and 1645-18B)	SOIs that met Criteria 1 to 3	Sections 2.4.4 and 3.2
An examination of water chemistry at the edge of the mixing zone (from SNP 1645-19A, 1645-19B2, 1645-19C)	SOIs that met Criteria 1 to 3	Sections 2.4.4 and 3.2
An assessment of the magnitude and extent of effects, as defined by the Action Level criteria in the Response Framework for water quality	All SOIs	Sections 2.4.5.1 and 3.5
An evaluation of spatial trends in SOI concentrations with distance from the diffusers, including linear regression analysis of data along the MF transects	SOIs that met Criteria 1 to 3	Sections 2.4.5.2 and 3.6
An examination of potential effects from dust deposition	SOIs that met Criterion 4	Sections 2.4.5.4 and 3.7

SNP = Surveillance Network Program; SOI = substance of interest.

2.4.2 Data Screening

Initial screening of the SNP and AEMP datasets was completed prior to data analyses to identify unusually high or low values and decide whether to exclude anomalous data from further analysis. An explanation of the objectives and approach taken to complete the initial screening is provided in the *Quality Assurance Project Plan Version 3.1* (Golder 2017b), or QAPP, and in Attachment C.

Results of the initial screening for anomalous values in the SNP and AEMP datasets are presented in Attachment C, Tables C-1 to C-3. The SNP data screening identified 14 anomalous values in the effluent dataset and seven anomalous values in the mixing zone dataset, representing 0.2% and 0.05% (respectively) of the data within each dataset. In total, 26 anomalous values were identified within the AEMP water quality dataset, representing 0.2% of the data. In cases where unusual values were identified in the SNP and AEMP datasets, scatterplots were generated to allow a visual review of the excluded data (Attachment C, Figures C-1 to C-13).

2.4.3 Censored Data

For the purpose of the AEMP, censored data are concentrations reported below the analytical DL (referred to as non-detect values). Due to the location of Lac de Gras on the Canadian Shield, concentrations of many water quality variables are low and are frequently measured at or below the DL. A commonly used, simple approach to deal with censored data is the substitution of a surrogate value (e.g., the DL or some fraction of the DL) for non-detect data, which is considered acceptable in cases when a relatively small proportion of the data (less than 15%) are below the DL (United States Environmental Protection Agency [US EPA] 2000).

Prior to data analyses, non-detect values were substituted with half the DL (i.e., 0.5 times the DL). This approach for handling censored data (US EPA 2000) is consistent with the approved methods applied in the calculation of the normal range in the *AEMP Reference Conditions Report Version 1.4* (Golder 2019a).

Data measured at less than the DL are presented on plots at half the DL. The non-parametric (i.e., percentile based) methods used to assess Action Levels for water quality in this report (Section 2.4.5.1) minimized the influence of using a substitution method for handling censored data. Handling of censored data in statistical analysis of water quality datasets is discussed in Section 2.4.5.2.

2.4.4 Effluent and Mixing Zone Assessment

The effluent discharge from the NIWTP to Lac de Gras was assessed in terms of quantity and quality. The period of effluent discharge summarized in this report was 1 November 2019 to 31 October 2020. Concentrations of SOIs at the mixing zone boundary are also presented.

2.4.4.1 Trends in Effluent and at the Mixing Zone Boundary

Trends in effluent quantity were evaluated graphically (i.e., as bar charts) by plotting total monthly discharge volumes (cubic metres per month) and loading rates (kilograms per month) of SOIs that met selection criteria 1 to 3 as defined in Section 2.4.1. Mean daily loads for each SOI were calculated by multiplying the discharge rate by the concentration for each effluent diffuser station (SNP 1645-18, SNP 1645-18B). Linear interpolation was used to estimate the concentrations between sampling events. The total monthly load was estimated as the sum of daily loads from the two diffusers. One SOI, turbidity (Section 3.1), was excluded from this assessment because load is not a relevant measure for turbidity.

Graphs showing the concentrations of SOIs in the effluent that met criteria 1 to 3 were generated for the 2020 discharge period. Results for individual grab samples were plotted separately for each station. Water sampling at the mixing zone boundary is completed monthly at surface and 5 m depth intervals at three stations (i.e., SNP 1645-19A, SNP 1645-19B2 and SNP 1645-19C). Therefore, up to 15 samples were collected each month. Results were summarized as boxplots showing 10th, 25th, 50th (i.e., median), 75th, and 90th percentile concentrations, circles represent the 5th and 95th percentile concentrations.

2.4.4.2 Comparison to Effluent Quality Criteria

The quality of the effluent discharged to Lac de Gras via the North Inlet was assessed by comparing water chemistry results at SNP 1645-18 and SNP 1645-18B with the EQC defined in the Water Licence (WLWB 2015) and in Table 2-4. In addition to the criteria listed in Table 2-4, all discharges from the NIWTP to Lac de Gras must have a pH between 6.0 to 8.4 (WLWB 2015). The comparison of phosphorus to the applicable EQC is discussed in the *Eutrophication Indicators Report* (Appendix XIII). Maximum average and maximum grab sample concentrations in the effluent from November 2019 to October 2020 were compared to the EQC for the Mine. Variables with concentrations in effluent that exceeded the EQC were included in the SOI list.

Table 2-4 Effluent Quality Criteria for Discharge to Lac de Gras

Variable	Units	Maximum Average Concentration	Maximum Concentration of Any Grab Sample
Total ammonia	µg-N/L	6,000	12,000
Total aluminum	µg/L	1,500	3,000
Total arsenic	µg/L	50	100
Total copper	µg/L	20	40
Total cadmium	µg/L	1.5	3
Total chromium	µg/L	20	40
Total lead	µg/L	10	20
Total nickel	µg/L	50	100
Total zinc	µg/L	10	20
Nitrite	µg-N/L	1,000	2,000
Total suspended solids	mg/L	15	25
Turbidity	NTU	10	15
Biochemical oxygen demand	mg/L	15	25
Total petroleum hydrocarbons	mg/L	3	5
Fecal coliforms	CFU/100 mL	10	20

Source: WLWB (2015)

µg-N/L = micrograms nitrogen per litre; NTU = nephelometric turbidity unit; CFU = colony forming units.

2.4.4.3 Comparison to Effects Benchmarks

Water quality in Lac de Gras at the edge of the mixing zone was compared to the AEMP Effects Benchmarks presented in Table 2-5. Variables with concentrations at the mixing zone boundary that exceeded AEMP Effects Benchmarks were included in the SOI list (Section 2.4.1). Water chemistry results at the edge of the mixing zone were also evaluated as part of the Action Level screening (Section 2.4.5.1).

Effects Benchmarks represent concentrations intended to protect human health or aquatic life. They are based on the Canadian Water Quality Guidelines (CWQGs) for the protection of aquatic life (CCME 1999), the Canadian Drinking Water Quality Guidelines (Health Canada 1996, 2020), guidelines from other jurisdictions (e.g., provincial and state guidelines), adaptations of general guidelines to site-specific conditions in Lac de Gras (Appendix IV.1 in DDMI 2007), or when appropriate, values from the scientific literature.

The CWQGs are intended to provide protection of freshwater life from anthropogenic stressors such as chemical inputs or physical changes (CCME 1999). These guidelines are based on current, scientifically-defensible toxicological data and are intended to protect all forms of aquatic life, including the most sensitive life stage of the most sensitive species over the long term. The Canadian Drinking Water Quality Guidelines are based on published scientific research related to health effects, aesthetic effects and operational considerations (Health Canada 1996, 2020). Health-based guidelines are established based on comprehensive review of the known health effects associated with each chemical, exposure levels, and availability of water treatment and analytical technologies. Aesthetic effects (e.g., taste, odour) are considered when these play a role in determining whether consumers will consider the water drinkable. For variables with both aquatic life and drinking water values, the Effects Benchmark is the lower of the two.

The Effects Benchmarks used for the AEMP are generally consistent with those established during the Environmental Assessment (EA), referred to as ecological thresholds in the EA, but have incorporated a number of revisions to maintain their relevance over time for the Lac de Gras environment. Under the Response Framework for water chemistry, an Effects Benchmark must be established for water quality variables that trigger Action Level 2 if an Effects Benchmark does not already exist. As a result, DDMI has developed Effects Benchmarks for seven variables: turbidity, dissolved calcium, dissolved sodium, total aluminum, total antimony, total silicon, and total tin (Golder 2017a, WLWB 2019).

In 2020, Effects Benchmarks for the protection of aquatic life were added for dissolved manganese and dissolved zinc based on the updated CWQG for these variables. The CWQG for dissolved zinc replaces the previous aquatic life Effects Benchmark for total zinc (30 µg/L). Seven additional variables (pH, barium, cadmium, lead, manganese, selenium, and strontium) have updated Health Canada drinking water guidelines, which are not yet reflected in the design plan (i.e., in either Versions 4.1 or 5.2) but are presented in Table 2-5. These updated guidelines were used in the screening presented herein.

Table 2-5 Effects Benchmarks for Water Quality Variables

Variable	Unit	Effects Benchmarks(a)	
		Protection of Aquatic Life	Drinking Water
Conventional Parameters			
Dissolved oxygen	mg/L	Cold water:	-
		early life stages = 9.5	
		other life stages = 6.5	
pH	pH Units	6.5 to 9.0	7.0 to 10.5(l)
Total dissolved solids	mg/L	500(b)	500
Total alkalinity	mg/L	n/a(c)	-
Total suspended solids	mg/L	+5 (24 h to 30 days)(d)	-
		+25 (24 h period)(d)	
Turbidity	NTU	2.2 (long term, IC)(e)	-
		2.3 (long term, OW)(e)	
Major Ions			
Calcium (dissolved)	mg/L	60(m)	
Chloride	mg/L	120	250
Fluoride	mg/L	0.12	1.5
Sodium (dissolved)	mg/L	52(e)	200
Sulphate	mg/L	100(f)	500
Nutrients			
Ammonia	µg-N/L	4,730(g)	-
Nitrate	µg-N/L	3,000	10,000
Nitrite	µg-N/L	60	1,000
Total Metals			
Aluminum (total)	µg/L	87(e)	100/200(h)
Aluminum (dissolved)	µg/L	Variable with pH(g,i)	-
Antimony	µg/L	33(e)	6
Arsenic	µg/L	5	10
Barium	µg/L	1,000(f)	2,000(l)
Boron	µg/L	1,500	5,000
Cadmium	µg/L	0.1(g)	7(l)
Chromium	µg/L	1 (Cr VI)(j)	50
Copper	µg/L	2	1,000
Iron	µg/L	300	300
Lead	µg/L	1	5(l)
Manganese (total)	µg/L	-	20(l)
Manganese (dissolved)	µg/L	Variable with pH and Hardness(n)	-
Mercury	µg/L	0.026 (inorganic); 0.004 (methyl)	1
Molybdenum	µg/L	73	-
Nickel	µg/L	25	-
Selenium	µg/L	1	50(l)
Silicon	µg/L	2,100(e)	-
Silver	µg/L	0.25	-
Strontium	µg/L	30,000(k)	7,000(l)
Thallium	µg/L	0.8	-
Tin	µg/L	73(e)	-
Uranium	µg/L	15	20
Zinc (total)	µg/L	-	5,000
Zinc (dissolved)	µg/L	Variable with pH, Hardness, and DOC(o)	-

Source: Golder (2020a)

a) Unless noted, benchmarks are derived from current Canadian Water Quality Guidelines and Canadian Drinking Water Quality Guidelines; the Effects Benchmark is selected as the lesser of the two values.

b) Adopted from Alaska DEC (2012) and as directed by the WLWB (2013).

c) Alkalinity should not be less than 25% of natural background level. There is no maximum guideline (US EPA 1998); because this benchmark involves a decrease in alkalinity and the Mine effluent is slightly alkaline, this benchmark is not applicable.

d) Average increase of 5 mg/L (over a period of 24 hours to 30 days) or maximum increase of 25 mg/L in a 24 h-period.

e) See Appendix B of the *AEMP Design Plan Version 4.1* (Golder 2017a) for description.

f) BC MOE (2013).

g) See Appendix IV.1 in DDMI (2007) and BC MOE (2001) for description.

h) 100 µg/L for conventional treatment and 200 µg/L for other treatment types.

i) Benchmark value (mg/L) = e[1.6−3.327(median pH)+0.402(median pH)^2] when median pH is less than 6.5 and is 50 µg/L when median pH is greater than or equal to 6.5 (BC MOE 2017).

j) Total chromium concentrations will be compared to the benchmark for chromium VI.

k) Based on results from HydroQual (2009) and Pacholski (2009).

l) Updated CCME or Health Canada drinking water guideline, which are not reflected in *AEMP Design Plan Version 4.1* or *AEMP Design Plan Version 5.2*.

m) See *AEMP Response Plan for Diavik Diamond Mine – Proposed Calcium Effects Benchmark* (Golder 2019d) for description.

n) The CWQG for manganese (i.e., long-term guideline) is found using the CWQG calculator in Appendix B of the Scientific Criteria Document for the Development of the Canadian Water Quality Guidelines for the Protection of Aquatic Life: Manganese (CCME 2019).

o) Benchmark value (µg/L) = e(0.947[ln(hardness mg·L^{-1})] - 0.815[pH] + 0.398[ln(DOC mg·L^{-1})] + 4.625). Where values for dissolved organic carbon (DOC) were not available, the minimum value for which the equation is valid (0.3 mg/L) was assumed.

- = benchmark not available; IC = ice-cover; OW = open-water; NTU = nephelometric turbidity unit; µg-N/L = micrograms nitrogen per litre; n/a = not applicable; DOC = dissolved organic carbon

2.4.4.4 Effluent Toxicity

Part H, Item 30 of the Water Licence (WLWB 2015) requires toxicity testing of effluent discharged to Lac de Gras (WLWB 2015), as follows:

- acute lethality to Rainbow Trout, *Oncorhynchus mykiss*, per Environment Canada's Environmental Protection Series Biological Test Method EPS/1/RM/13
- acute lethality to the crustacean, *Daphnia magna*, per Environment Canada's Environmental Protection Series Biological Test Method EPS/1/RM/14
- chronic toxicity to the amphipod, *Hyalella azteca*, per a water-only protocol approved by the WLWB, if the maximum average concentration of total ammonia exceeds 3 mg/L at either SNP Station 1645-18 or 1645-18B
- chronic toxicity to early life stages of salmonid fish, per Environment Canada's Environmental Protection Series Biological Test Method EPS/1/RM/28
- chronic toxicity to the crustacean, *Ceriodaphnia dubia*, per Environment Canada's Environmental Protection Series Biological Test Method EPS/1/RM/21
- chronic toxicity to the freshwater alga, *Pseudokirchneriella subcapitata*, per Environment Canada's Environmental Protection Series Biological Test Method EPS/1/RM/25

These toxicity tests are completed on a quarterly basis. *Hyalella azteca* testing, however, is only required if elevated levels of ammonia are observed in the treated effluent (see the Revision History Table in Annex 1 of the Water Licence [WLWB 2015]).

Effluent samples were submitted to BV Labs in Burnaby, BC, or Edmonton, AB, Canada and Nautilus Environmental in Burnaby for toxicity testing. The effluent toxicity data collected during the 2020 reporting period were used to evaluate whether Mine effluent had the potential to cause toxic responses in biota in Lac de Gras.

The results of lethal and sublethal toxicity testing carried out on effluent samples from SNP 1645-18 and SNP 1645-18B were summarized for the 2020 reporting period. Results for lethal tests are presented as a “pass” or “fail” to be consistent with laboratory procedures and standards. A lethal test was considered a fail if a result of greater than or equal to 50% mortality in 100% effluent was obtained. Although not a requirement under the Water Licence, a sublethal test was considered a fail if the test results demonstrated sublethal effects greater than or equal to 50%, relative to the control.

2.4.5 AEMP Water Quality Assessment

2.4.5.1 Action Level Evaluation

Water quality variables were assessed for a Mine-related effect as described in the *AEMP Design Plan Version 4.1* (Golder 2017a) Response Framework. The Action Levels for water quality were developed to meet the goals of the draft *Guidelines for Adaptive Management – A Response Framework for Aquatic Effects Monitoring* (WLWB 2010; Racher et al. 2011). The main goal of the Response Framework is to ensure that significant adverse effects never occur. This is accomplished by requiring proponents to take action at pre-defined Action Levels, which are triggered well before significant adverse effects could occur (Table 2-6). A significant adverse effect, as it pertains to water quality, was defined in the EA as a concentration of a variable that exceeds an established guideline for the protection of aquatic life and drinking water quality by more than 20% (Golder 2017a). This effect must have a high probability of being permanent or long-term in nature and must occur throughout Lac de Gras.

Water quality is assessed annually relative to Action Levels for water chemistry (Table 2-6). Magnitude of effects on water chemistry variables was determined by comparing concentrations between NF, MF, and FF sampling areas, reference conditions, and benchmark values. Reference conditions for Lac de Gras are those that fall within the range of natural variability, referred to as the normal range. The normal ranges used in the Action Level screening for water quality are described in the *AEMP Reference Conditions Report Version 1.4* (Golder 2019a) and are summarized in Table 2-7. The water quality benchmark values used in the Action Level assessment (referred to herein as Effects Benchmarks), are discussed in Section 2.4.4.3 and are presented in Table 2-5. The magnitude of effect was classified according to the appropriate Action Level (Table 2-6).

Action Levels were assessed separately for the ice-cover and open-water seasons. The ice-cover season was defined as November to June, and the open-water season was defined as July to October. The results for all depths and stations sampled, both at the mixing zone boundary and at AEMP stations, were included in the calculation of the 2020 exposure values considered at each Action Level (Table 2-6).

Box and whisker plots were generated for SOIs that triggered an Action Level, to illustrate spatial variation in water quality in Lac de Gras and to show the 2019 results relative to the Action Levels. The box was bound by the 25th and 75th quantiles, with a thick line showing the median value. The whiskers depicted the 10th and 90th quantiles, and points were used to show the 5th and 95th quantiles. Non-detect values were plotted at half the DL, to be consistent with data handling procedures used in the evaluation of Action Levels and estimation of the normal range (Golder 2019a).

Table 2-6 Action Levels for Water Chemistry, Excluding Indicators of Eutrophication

Action Level	Magnitude of Effect[a]	Extent of Effect	Action/Note
1	Median of NF greater than 2 times the median of reference dataset[b] (open-water or ice-cover) and strong evidence of link to Mine	NF	Early warning.
2	5th percentile of NF values greater than 2 times the median of reference areas AND normal range[b]	NF	Establish Effects Benchmark if one does not exist.
3	75th percentile of MZ values greater than normal range plus 25% of Effects Benchmark[c]	MZ	Confirm site-specific relevance of Effects Benchmark. Establish Effects Threshold. Define the Significance Threshold if it does not exist. The WLWB to consider developing an EQC if one does not exist
4	75th percentile of MZ values greater than normal range plus 50% of Effects Threshold[c]	MZ	Investigate mitigation options.
5	95th percentile of MZ values greater than Effects Threshold	MZ	The WLWB to re-assess EQC. Implement mitigation required to meet new EQC if applicable.
6	95th percentile of NF values greater than Effects Threshold + 20%	NF	The WLWB to re-assess EQC. Implement mitigation required to meet new EQC if applicable.
7	95th percentile of MF values greater than Effects Threshold + 20%	MF	The WLWB to re-assess EQC. Implement mitigation required to meet new EQC if applicable.
8	95th percentile of FFB values greater than Effects Threshold + 20%	FFB	The WLWB to re-assess EQC. Implement mitigation required to meet new EQC if applicable.
9	95th percentile of FFA values greater than Effects Threshold + 20%	FFA	Significance Threshold.[d]

a) Calculations were based on pooled data from all depths.

b) Normal ranges and reference datasets were obtained from the *AEMP Reference Conditions Report Version 1.4* (Golder 2019a); the normal range for open-water was based on the 15 August to 15 September period. In cases where the reference area median value reported in the reference conditions report was equal to the DL, half the DL was used to calculate the 2× reference area median criterion, to be consistent with data handling methods used for the AEMP.

c) Indicates 25% or 50% of the difference between the Effects Benchmark/Threshold and the top of the normal range.

d) Although the Significance Threshold is not an Action Level, it is presented as the highest Action Level to show escalation of effects towards the Significance Threshold.

NF = near-field; MZ = mixing zone; MF = mid-field; FF = far-field; WLWB = Wek'èezhìı Land and Water Board; EQC = Effluent Quality Criteria.

Table 2-7 Normal Ranges for Water Chemistry Variables

Variable	Unit	Normal Range			
		Ice-cover		Open-water	
		Lower Limit	Upper Limit	Lower Limit	Upper Limit
Conventional Parameters					
Total alkalinity	mg/L	3.2	6.0	3.1	4.7
Total hardness	mg/L	5.0	7.0	4.0	6.0
Total dissolved solids, calculated	mg/L	2.9	6.5	3.8	5.8
Total dissolved solids, measured	mg/L	0	24	0	20
Total suspended solids	mg/L	0	1.0	0	1.0
Total organic carbon	mg/L	2.0	3.1	1.9	3.0
Turbidity – lab	NTU	0	0.18	0.13	0.29
Major Ions					
Calcium (dissolved)	mg/L	0.9	1.3	0.8	1.1
Chloride	mg/L	0	1.0	0	1.0
Fluoride	mg/L	0.02	0.03	0.019	0.03
Magnesium (dissolved)	mg/L	0.6	0.8	0.6	0.8
Potassium (dissolved)	mg/L	0.5	0.8	0.4	0.7
Sodium (dissolved)	mg/L	0	1.0	0	1.0
Sulphate	mg/L	1.9	2.5	1.7	2.1
Nutrients					
Ammonia	µg-N/L	14.3	23	0	5.0
Nitrate	µg-N/L	0	15.2	0	2.0
Nitrite	µg-N/L	0	2.0	0	2.0
Total Metals					
Aluminum	µg/L	2.3	3.9	3.4	6.2
Antimony	µg/L	0	0.02	0	0.02
Arsenic	µg/L	0.15	0.22	0.16	0.19
Barium	µg/L	1.74	2.18	1.61	1.94
Beryllium	µg/L	0	0.01	0	0.01
Bismuth	µg/L	0	0.005	0	0.005
Boron	µg/L	0	5.0	0	5.0
Cadmium	µg/L	0	0.005	0	0.005
Calcium	mg/L	0.94	1.15	0.87	1.00
Chromium	µg/L	0	0.06	0	0.06
Cobalt	µg/L	0.01	0.02	0.01	0.04
Copper	µg/L	0	0.8	0	0.6
Iron	µg/L	0	5.0	0	7.6
Lead	µg/L	0	0.007	0	0.006
Lithium	µg/L	1.2	1.5	1.2	1.3
Magnesium	mg/L	0.59	0.79	0.58	0.66
Manganese	µg/L	0.60	1.95	1.54	4.67
Mercury	µg/L	0	0.01	0	0.01
Molybdenum	µg/L	0.06	0.09	0.07	0.13
Nickel	µg/L	0.83	1.10	0.72	1.12
Potassium	mg/L	0.53	0.67	0.50	0.57
Selenium	µg/L	0	0.04	0	0.04
Silicon	µg/L	0	50	0	50
Silver	µg/L	0	0.005	0	0.005
Sodium	mg/L	0.56	0.75	0.55	0.68
Strontium	µg/L	6.70	8.78	6.51	8.01
Sulphur	mg/L	0.84	1.07	0.83	1.32
Thallium	µg/L	0	0.002	0	0.002
Tin	µg/L	0	0.01	0	0.01
Titanium	µg/L	0	0.5	0	0.5
Uranium	µg/L	0.027	0.030	0.024	0.029
Vanadium	µg/L	0	0.1	0	0.1
Zinc	µg/L	0.37	1.53	0.29	2.04
Zirconium	µg/L	0	0.05	0	0.05

Source: *AEMP Reference Conditions Report Version 1.4* (Golder 2019a)

NTU = nephelometric turbidity unit; µg-N/L micrograms nitrogen per litre.

2.4.5.2 Gradient Analysis

The spatial gradients in water quality SOIs along the three MF transects were analyzed using linear regression, per the *AEMP Design Plan Version 4.1* (Golder 2017a). The NF area data were included in the linear regression for each of the three MF transects. Hereafter, the NF-MF1-FFD-FF1 transect is referred to as the MF1 transect, the NF-MF2 transect is referred to as the MF2 transect, and the NF-MF3 transect is referred to as MF3 transect. The stations included in each of the MF transects are described in Section 2.1. The maximum values of top, middle and bottom depth samples for the three MF transects were used in the regression analysis. Regression analyses were considered significant at $\alpha = 0.05$.

Due to the spatial span of the MF3 transect, variables often had non-linear patterns with distance from the diffusers. Therefore, the analysis method allowed for piecewise regression (also referred to as segmented, or broken stick regression). Two approaches were used:

- Model 1: a linear multiplicative model, with main effects of distance from diffusers, gradient (MF1, MF2, and MF3 transects), and their interaction
- Piecewise modeling to account for changes in spatial gradients, where individual transects were analyzed separately from one another:
  - Model 2: a linear multiplicative model, with main effects of distance from diffusers, gradient (only MF1 and MF2 transects), and their interaction
  - Model 3: a linear piecewise (broken stick) model with distance (MF3 transect only)

For each variable in each season, Model 1 was used to test for presence of a significant ($P<0.05$) breakpoint (i.e., where the slopes of the linear regressions changed) using the Davies test (Davies 1987, 2002). If a significant breakpoint was identified, Models 2 and 3 were used for that variable in that season. If no significant breakpoint was identified, Model 1 was used for that variable in that season.

Following the initial fit of the model, the residuals (of either Model 1 or Model 2, as applicable) were examined for normality. Model 3 was not considered for transformations since the addition of a breakpoint was expected to resolve non-linear patterns. Box-Cox transformations were applied to the datasets for each variable (Box and Cox 1964). The Box-Cox transformations are a family of transformations that include the commonly used log and square root transformations. The Box-Cox transformation process tests a series of power values, usually between -2 and +2, and records the log-likelihood of the relationship between the response and the predictor variables under each transformation. The transformation that maximizes the log-likelihood is the one that will best normalize the data. Therefore, the data are transformed using a power value (λ) identified by the transformation process. For a λ of zero, the data are natural log transformed. The transformation rules can be described using the following definitions:

$$\text{Transformed value} = \frac{\text{value}^{\lambda} - 1}{\lambda} \quad \text{if } \lambda \neq 0$$

$$\text{Transformed value} = \ln(\text{value}) \quad \text{if } \lambda = 0$$

The selected transformation was applied to all data (i.e., a transformation selected based on Model 2 was also applied to MF3 data).

Following data transformation (if required), the selected models were fitted to the data. Statistical outliers were identified using studentized residuals with absolute values of 3.5 or greater, or due to consideration of leverage (where a single point could strongly influence the overall fit of the model). All values removed from the analysis were retained for plots of model predictions, where they were presented using a different symbol from the rest of the data.

Following removal of outliers, breakpoint significance and data transformation were re-examined. Residuals from the refitted models were examined for normality, heteroscedasticity, and evidence of non-linear patterns. If non-linearity was evident from residual examination, the analysis was terminated and data were presented qualitatively. If normality was evident, three models were constructed to assess the effect of heteroscedasticity for each response variable in each season:

- heteroscedasticity by gradient (applied only to Models 1 and 2)
- heteroscedasticity by predicted value (accounting for the classic trumpet shape of heteroscedastic data)
- heteroscedasticity by distance from the diffuser

These three models were compared to the original model that did not account for heteroscedasticity, using Akaike's information criterion (AIC), corrected for small sample size (AICc). The model with the lowest AIC score among a set of candidate models was interpreted to have the strongest support, given the set of examined models and the collected data (Burnham and Anderson 2002), and thus was selected for interpretation. When using AIC not corrected for small sample size, models with AIC scores within two units of each other are considered to have similar levels of support (Arnold 2010). Since the small sample size correction was used in the analysis, the cut-off value was adjusted to reflect the higher penalization of model parameters (the adjustment depended on the number of data points and model parameters).

The constructed models were used to produce the following outputs:

- estimates and significance of slopes (i.e., distance effects) for each gradient; in the case of MF3 data analyzed using piecewise regression, the significance of the first slope, extending from the NF to the breakpoint, was calculated
- the r^2 value of each model, to examine explained variability
- fitted prediction lines and 95% confidence intervals (back-transformed to original scale of the variable)

Analyses were performed using the statistical environment R and package "segmented" (Muggeo 2008).

Based on US EPA guidance, a screening value of greater than 15% censoring was used to flag datasets that may not be amenable to the linear regression analysis (US EPA 2000). The decision of whether to analyze the data using linear regression was based on review of the number of values less than the DL (<DL) according to variable and season. Because of large numbers of values <DL, linear regression analysis was not performed for:

- turbidity: ice-cover (73% <DL) and open-water (44% <DL)
- total suspended solids (TSS): ice-cover (72% <DL) and open-water (34% <DL)

- nitrate: open-water (26% <DL)
- antimony: ice-cover (52% <DL) and open-water (72% <DL)
- chromium: ice-cover (48% <DL) and open-water (43% <DL)
- silicon: ice-cover (58% <DL) and open-water (46% <DL)

Scatterplots of concentrations according to distance from the effluent discharge have been included for variables that had large numbers of values that were less than the DL.

2.4.5.3 Comparison to Effects Benchmarks

The field and analytical data obtained from the AEMP water quality sampling programs were compared to Effects Benchmarks presented in the *AEMP Design Plan Version 4.1* (Golder 2017a) and in Table 2-5. These water quality benchmark values were also used in the Action Level screening at Action Level 3 (Section 2.4.5.1).

2.4.5.4 Effects from Dust Deposition

The AEMP water quality data analysis included an evaluation of effects on water quality at stations potentially affected by Mine-related dust emissions. Based on the analysis conducted for the last re-evaluation (Golder 2020b), the dust ZOI is estimated to extend between 3.7 and 4.8 km from the geographic centre of the Mine (Mine centroid), or between 0.3 and 4.2 km from the boundary of the Mine footprint. These distances were estimated based on gradient analysis of dust deposition relative to distance from the Mine site and encompass the area of the lake where potential effects would be expected to be measurable (Golder 2020b). Beyond this estimated zone, dust deposition levels are similar to background levels. The AEMP sampling stations that fall within the expected ZOI from dust deposition include the five stations in the NF area, and stations MF1-1, MF3-1, MF3-2, and MF3-3[3].

The combined effects from discharge of Mine effluent and potentially dust deposition on water quality in the NF area were assessed according to the water quality Action Level 1 criteria (Section 2.4.5.1). A similar analysis was used to evaluate potential effects from dust emissions at affected stations in the MF area. Water quality variables at the aforementioned four MF stations with median concentrations (i.e., of top, middle, and bottom samples) that exceeded 2× the median of reference area data (i.e., the same criterion used in the assessment of Action Level 1 in the NF area) were considered potentially affected by dust emissions, in addition to potential effluent effects. This comparison was only considered for the open-water season data, because dust that is deposited on the ice during winter does not enter lake water until ice-off. If a variable triggered an effect equivalent to Action Level 1 at the MF stations identified above, but not the NF area (i.e., where the concentration of effluent is greatest), it was considered that the effects at these stations may have been influenced by dust deposition, or a combination of dust deposition and effluent discharge.

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[3] The list of stations included in the dust ZOI is based on the revised ZOI delineated in the *2017 to 2019 Aquatic Effects Re-evaluation Report* (Golder 2020d). Station MF2-1 was previously considered to be within in the ZOI, but is no longer expected to be measurably affected by dust. Station MF3-3 now falls within the revised dust ZOI.

3 RESULTS

3.1 Substances of Interest

Twenty-eight variables met the criteria for inclusion as SOIs in 2020 (Table 3-1) per the selection procedure described in Section 2.4.1:

- *Criterion 1:* None of the effluent chemistry variables with EQC were added to the SOI list because concentrations in individual grab samples were less than EQC for the maximum average concentration (Section 3.2.4) in all samples analyzed during the 2020 reporting period.
- *Criterion 2:* None of the mixing zone water chemistry variables with Effects Benchmarks were added to the SOI list because concentrations in all samples analyzed during the 2020 reporting period were below the relevant Effects Benchmarks (Section 3.2.5).
- *Criterion 3:* Twenty-one variables were added to the list of SOIs because they triggered Action Level 1 (Section 3.5.1): TDS, TSS, turbidity, calcium, chloride, magnesium, potassium, sodium, sulphate, ammonia, nitrate, aluminum, antimony, barium, chromium, copper, molybdenum, silicon, strontium, sulphur, and uranium.
- *Criterion 4:* Seven additional variables were added as SOIs as a result of applying this criterion: boron, cobalt, iron, lead, thallium, tin, and zinc. Eighteen of the SOIs selected under Criterion 3 also triggered an effect equivalent to Action Level 1 at one or more of the four MF area stations located within the estimated ZOI from dust deposition from the Mine site (Section 3.7): TDS, TSS, calcium, chloride, magnesium, potassium, sodium, sulphate, ammonia, nitrate, aluminum, antimony, copper, molybdenum, silicon, strontium, sulphur, and uranium. The triggers at the MF stations for these variables were likely caused by dispersion of Mine effluent within the lake.

Table 3-1 Water Quality Substances of Interest, 2020

Substance of Interest	Substances of Interest Criteria			
	1 Effluent Screening	2 Mixing Zone Screening	3 Action Level 1	4 Potential Dust Effects
Conventional Parameters				
Total dissolved solids, calculated	-	-	X	X
Total suspended solids	-	-	X	X
Turbidity – lab	-	-	X	-
Major Ions				
Calcium (dissolved)	-	-	X(a)	X(a)
Chloride	-	-	X	X
Magnesium (dissolved)	-	-	X(a)	X(a)
Potassium (dissolved)	-	-	X(a)	X(a)
Sodium (dissolved)	-	-	X(a)	X(a)
Sulphate	-	-	X	X
Nutrients				
Ammonia	-	-	X	X
Nitrate	-	-	X	X
Total Metals				
Aluminum	-	-	X	X
Antimony	-	-	X	X
Barium	-	-	X	-
Boron	-	-	-	X
Chromium	-	-	X	-
Cobalt	-	-	-	X
Copper	-	-	X	X
Iron	-	-	-	X
Lead	-	-	-	X
Molybdenum	-	-	X	X
Silicon	-	-	X	X
Strontium	-	-	X	X
Sulphur	-	-	X	X
Thallium	-	-	-	X
Tin	-	-	-	X
Uranium	-	-	X	X
Zinc	-	-	-	X

a) Both the total and dissolved fractions of calcium, magnesium, potassium, and sodium triggered Action Level 1 and an effect equivalent to Action Level 1 at one or more of the four mid-field (MF) area stations located within the estimated zone of influence (ZOI) from dust deposition from the Mine site. Review of the analytical data in 2020 indicated that some major ions and dissolved metals AEMP samples from the open-water season were potentially contaminated (Section 2.3.2; Attachment B); therefore, analyses involving the AEMP data were presented for the total fractions.

X = criterion met; - = criterion not met.

3.2 Trends in Effluent and at the Mixing Zone Boundary

3.2.1 Conventional Variables, Total Dissolved Solids, and Associated Ions

The conventional variables and major ions that met Criterion 3 of the SOI selection process (Section 2.4.1) included turbidity, TSS, TDS, calcium, chloride, magnesium, potassium, sodium, and sulphate. Loads of these variables, together with their concentrations in effluent and at the mixing zone, are presented in Figure 3-1 to Figure 3-9.

The turbidity of the effluent discharged from the NIWTP remained within a similar range over the 2020 monitoring period (Figure 3-1A). Median turbidity values at the mixing zone boundary varied without a distinct pattern, with the lowest median values occurring in February and May, and the highest values occurring in November (Figure 3-1B).

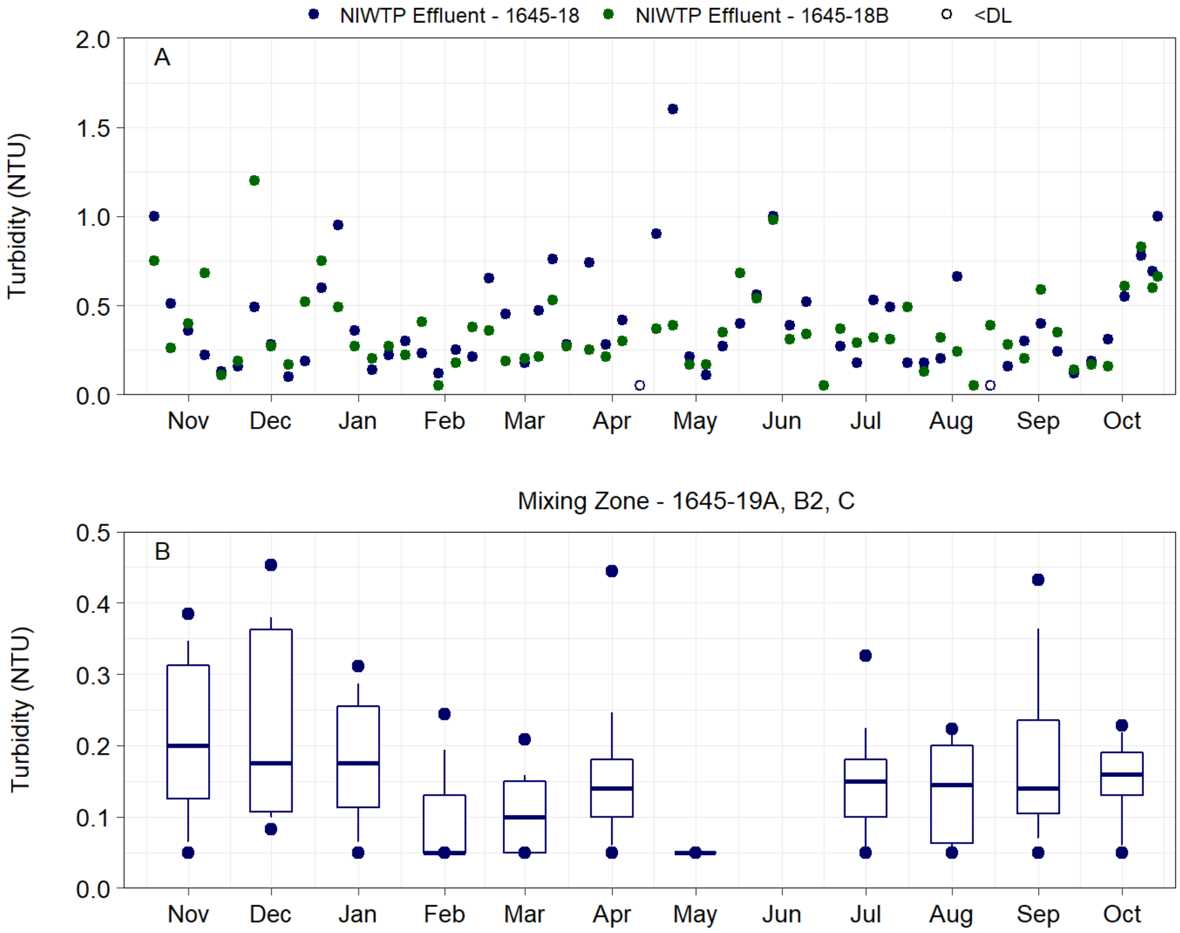
The monthly loads of TSS from the NIWTP remained within a similar range through April, and then increased in the late ice-cover season, peaking in June, before decreasing in the late open-water season, reflecting variation in the monthly volume of effluent discharged (Figure 3-2A). The TSS concentration in effluent remained within a similar range over the 2020 monitoring period (Figure 3-2A). Median TSS values at the mixing zone boundary were below the detection limit in most months with the exception of August and September (Figure 3-2C).

The monthly loads of TDS and associated ions (i.e., calcium, chloride, magnesium, potassium, sodium, and sulphate) from the NIWTP remained within a similar range through April, reflecting the variation in the monthly volume of effluent discharged (Figure 3-3A to Figure 3-9A). The loads of these SOIs increased during the late ice-cover and early open-water seasons, peaking in June (calcium, sodium), July (chloride), or August (TDS, magnesium, potassium, sulphate) before decreasing through the remainder of the open-water season as flow rates from the NIWTP decreased.

The concentrations of TDS, calcium, magnesium, potassium, and sodium in the effluent decreased from November to December. Calcium concentrations generally increased gradually over the remainder of the ice-cover season and then remained within a similar range through the open-water season (Figure 3-4B). The concentrations of TDS, magnesium, potassium, and sodium remained within a similar range from January until March or April, and then generally increased through the remainder of the reporting period (Figure 3-3B, Figure 3-6B, Figure 3-7B, and Figure 3-8B). The concentration of chloride remained within a similar range until March, increased in April and May, and then decreased in June, before gradually increasing during the open-water season (Figure 3-5B). The concentration of sulphate decreased from November through April, and then increased from May to August, before subsequently decreasing through the late open-water season (Figure 3-9B).

The median concentrations of TDS and associated ions at the mixing zone boundary increased from November to January and then remained within a similar range through the ice-cover season, with the exception of a decrease in concentrations in February (Figure 3-3C to Figure 3-9C). Median concentrations were lower during the open-water season for these SOIs, with the exception of potassium and sulphate, which had open-water concentrations similar to ice-cover concentrations. Concentrations of most of these SOIs at the mixing zone boundary were more variable during ice-cover compared to the open-water season.

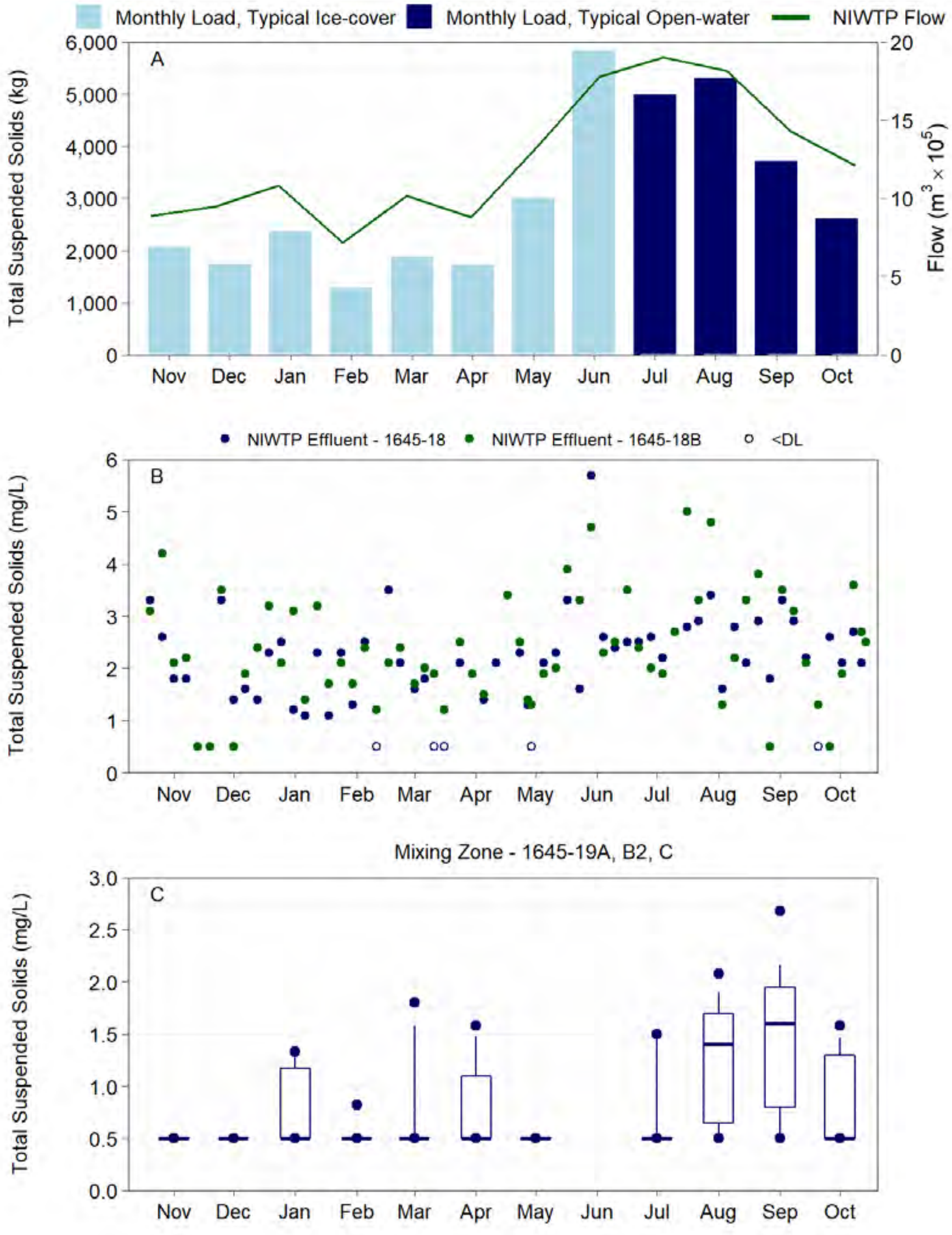
Figure 3-1 Turbidity: A) North Inlet Water Treatment Plant Effluent (SNP 1645-18 and SNP 1645-18B) and B) Mixing Zone Boundary (SNP 1645-19), 1 November 2019 to 31 October 2020



Notes: Effluent values represent concentrations in individual samples. Mixing zone boxplots represent the 10th, 25th, 50th (i.e., median), 75th, and 90th percentile concentrations at three stations (i.e., 1645-19A, 1645-19B2, 1645-19C) and five depths (i.e., 2 m, 5 m, 10 m, 15 m, and 20 m); circles represent the 5th and 95th percentile concentrations. The mixing zone samples could not be collected in June 2020 due to unsafe ice conditions.

NIWTP = North Inlet Water Treatment Plant; SNP = Surveillance Network Program.

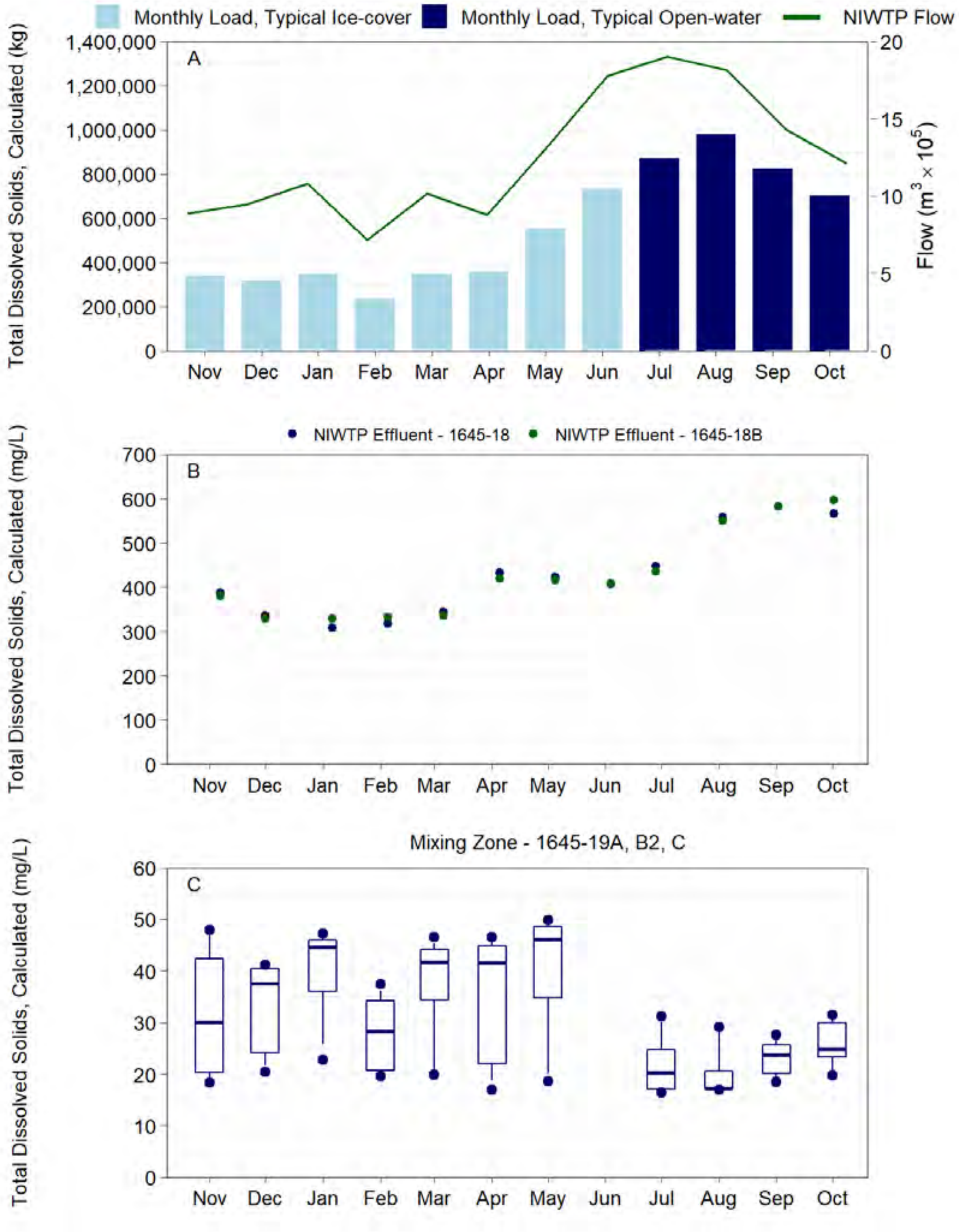
Figure 3-2 **Total Suspended Solids: A) Monthly Loading Rate from the North Inlet Water Treatment Plant, B) Concentration in Effluent (SNP 1645-18 and SNP 1645-18B), and C) Concentration at Mixing Zone Boundary (SNP 1645-19), 1 November 2019 to 31 October 2020**



Notes: Effluent values represent concentrations in individual samples. Mixing zone boxplots represent the 10th, 25th, 50th (median), 75th, and 90th percentile concentrations at three stations (i.e., 1645-19A, 1645-19B2, 1645-19C) and five depths (i.e., 2 m, 5 m, 10 m, 15 m, and 20 m); circles represent the 5th and 95th percentile concentrations. The mixing zone samples could not be collected in June 2020 due to unsafe ice conditions.

NIWTP = North Inlet Water Treatment Plant; SNP = Surveillance Network Program.

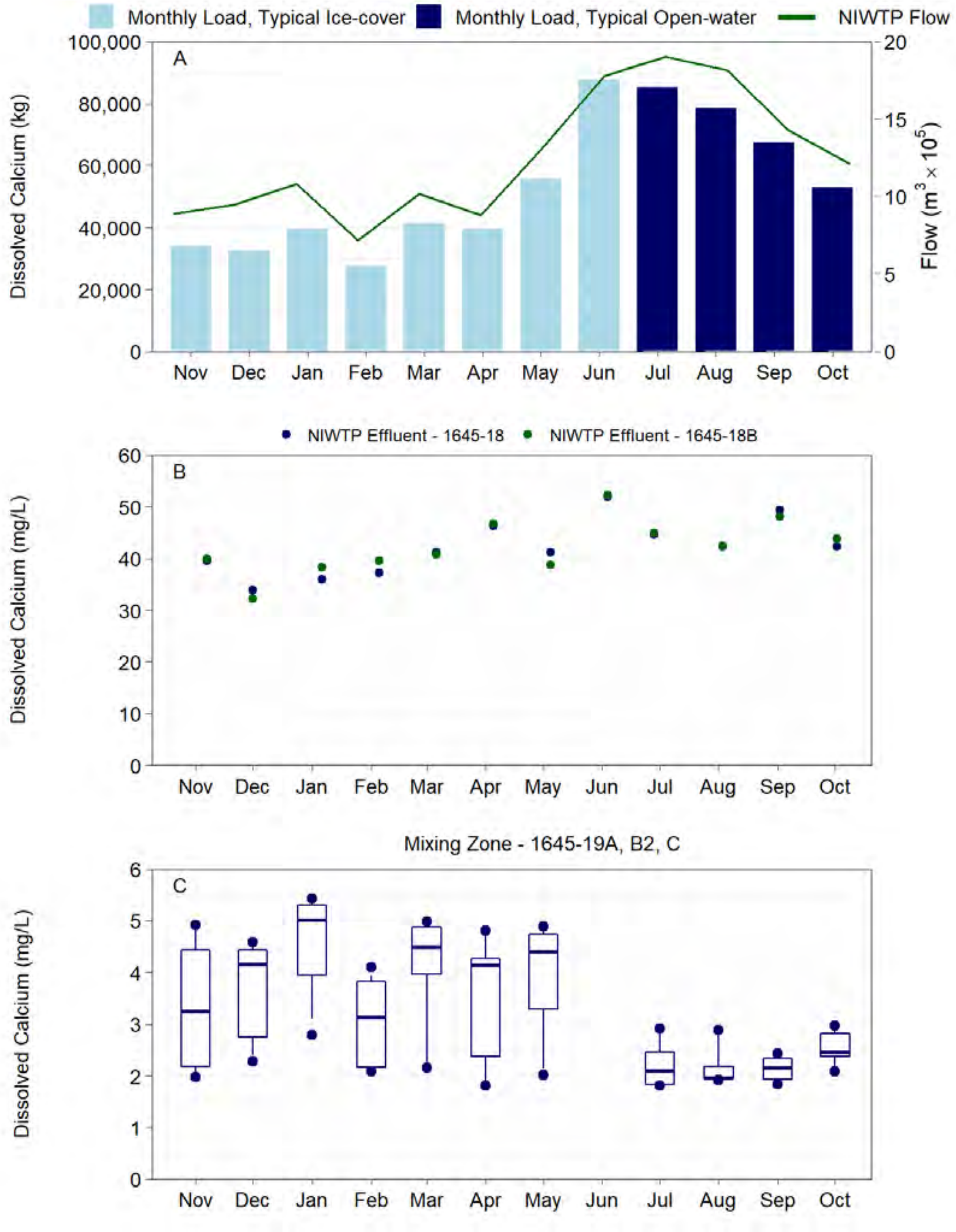
Figure 3-3 **Total Dissolved Solids, Calculated: A) Monthly Loading Rate from the North Inlet Water Treatment Plant, B) Concentration in Effluent (SNP 1645-18 and SNP 1645-18B), and C) Concentration at the Mixing Zone Boundary (SNP 1645-19), 1 November 2019 to 31 October 2020**



Notes: Effluent values represent concentrations in individual samples. Mixing zone boxplots represent the 10th, 25th, 50th (median), 75th, and 90th percentile concentrations at three stations (i.e., 1645-19A, 1645-19B2, 1645-19C) and five depths (i.e., 2 m, 5 m, 10 m, 15 m, and 20 m); circles represent the 5th and 95th percentile concentrations. The mixing zone samples could not be collected in June 2020 due to unsafe ice conditions.

NIWTP = North Inlet Water Treatment Plant; SNP = Surveillance Network Program.

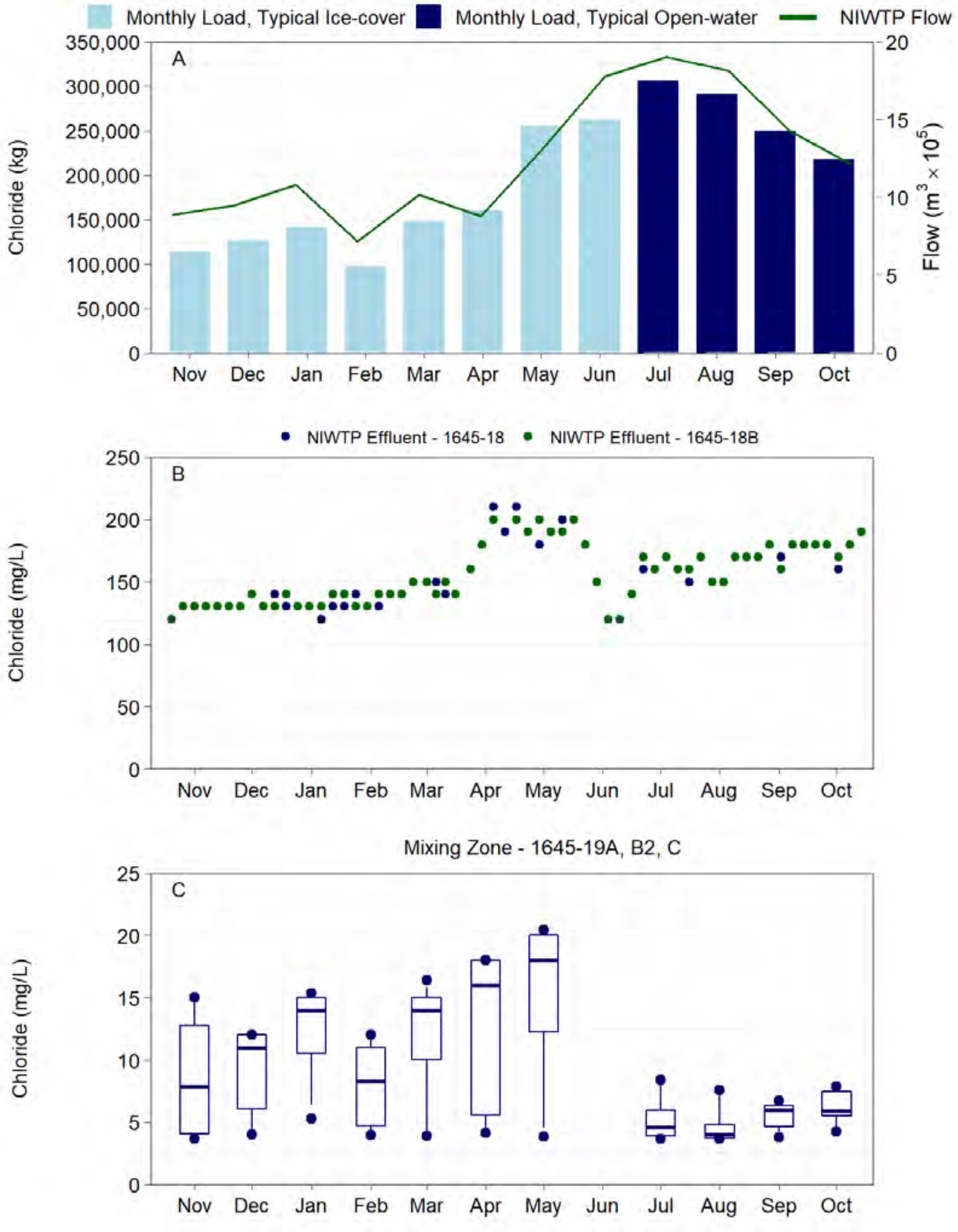
Figure 3-4 **Calcium (Dissolved): A) Monthly Loading Rate from the North Inlet Water Treatment Plant, B) Concentration in Effluent (SNP 1645-18 and SNP 1645-18B), and C) Concentration at the Mixing Zone Boundary (SNP 1645-19), 1 November 2019 to 31 October 2020**



Notes: Effluent values represent concentrations in individual samples. Mixing zone boxplots represent the 10th, 25th, 50th (median), 75th, and 90th percentile concentrations at three stations (i.e., 1645-19A, 1645-19B2, 1645-19C) and five depths (i.e., 2 m, 5 m, 10 m, 15 m, and 20 m); circles represent the 5th and 95th percentile concentrations. The mixing zone samples could not be collected in June 2020 due to unsafe ice conditions.

NIWTP = North Inlet Water Treatment Plant; SNP = Surveillance Network Program.

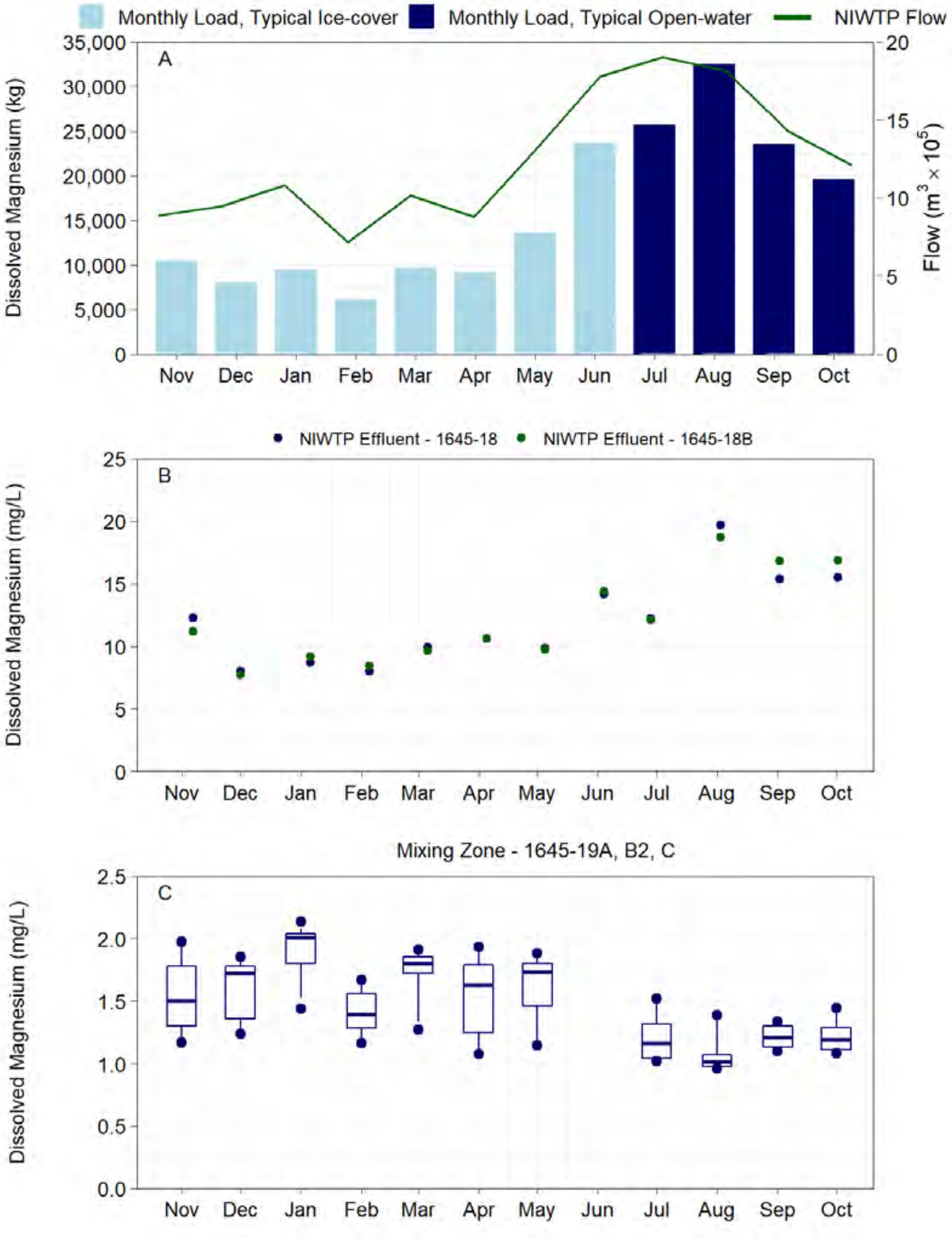
Figure 3-5 **Chloride: A) Monthly Loading Rate from the North Inlet Water Treatment Plant, B) Concentration in Effluent (SNP 1645-18 and SNP 1645-18B), and C) Concentration at the Mixing Zone Boundary (SNP 1645-19), 1 November 2019 to 31 October 2020**



Notes: Effluent values represent concentrations in individual samples. Mixing zone boxplots represent the 10th, 25th, 50th (median), 75th, and 90th percentile concentrations at three stations (i.e., 1645-19A, 1645-19B2, 1645-19C) and five depths (i.e., 2 m, 5 m, 10 m, 15 m, and 20 m); circles represent the 5th and 95th percentile concentrations. The mixing zone samples could not be collected in June 2020 due to unsafe ice conditions.

NIWTP = North Inlet Water Treatment Plant; SNP = Surveillance Network Program.

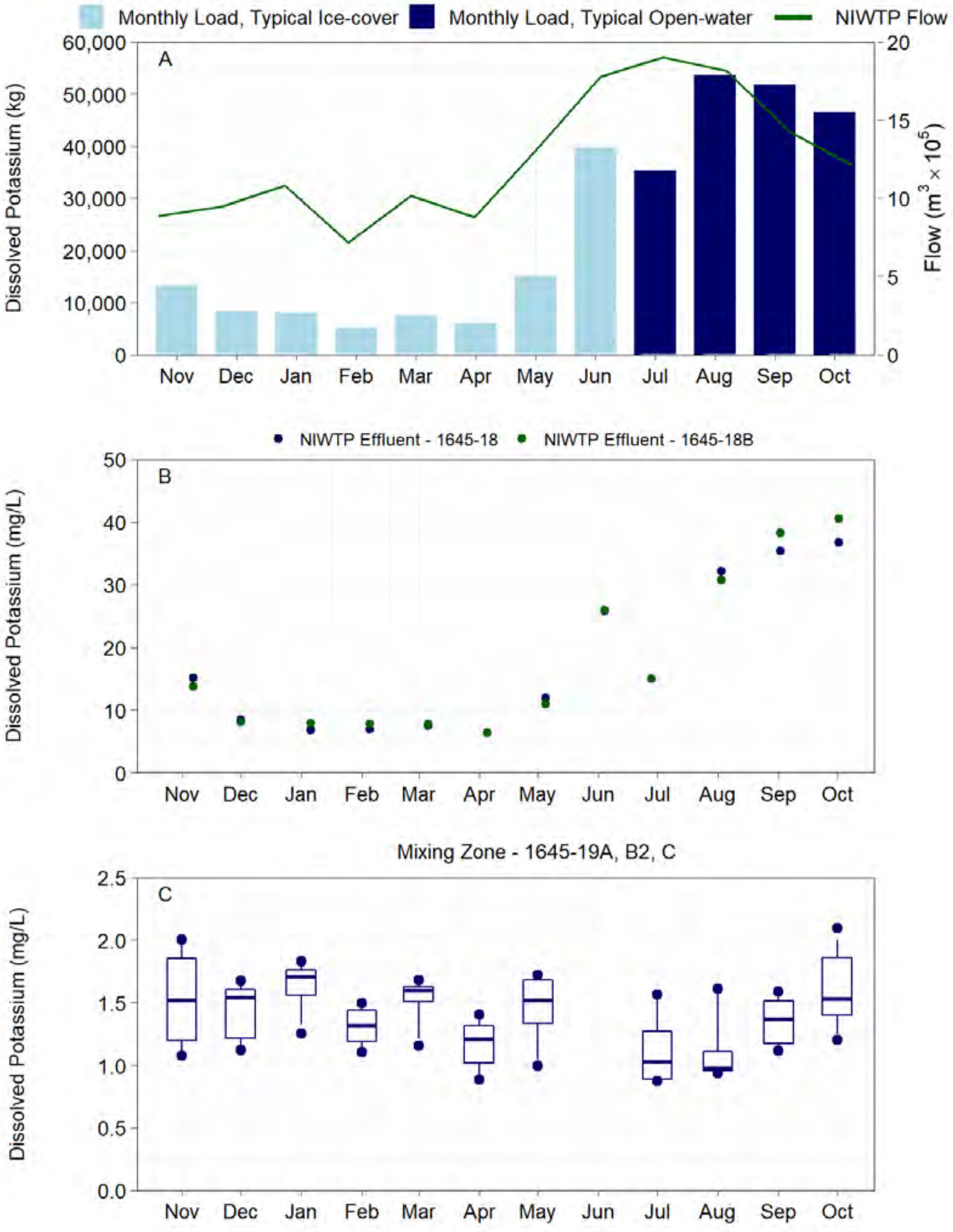
Figure 3-6 **Magnesium (Dissolved): A) Monthly Loading Rate from the North Inlet Water Treatment Plant, B) Concentration in Effluent (SNP 1645-18 and SNP 1645-18B), and C) Concentration at the Mixing Zone Boundary (SNP 1645-19), 1 November 2019 to 31 October 2020**



Notes: Effluent values represent concentrations in individual samples. Mixing zone boxplots represent the 10th, 25th, 50th (median), 75th, and 90th percentile concentrations at three stations (i.e., 1645-19A, 1645-19B2, 1645-19C) and five depths (i.e., 2 m, 5 m, 10 m, 15 m, and 20 m); circles represent the 5th and 95th percentile concentrations. The mixing zone samples could not be collected in June 2020 due to unsafe ice conditions.

NIWTP = North Inlet Water Treatment Plant; SNP = Surveillance Network Program.

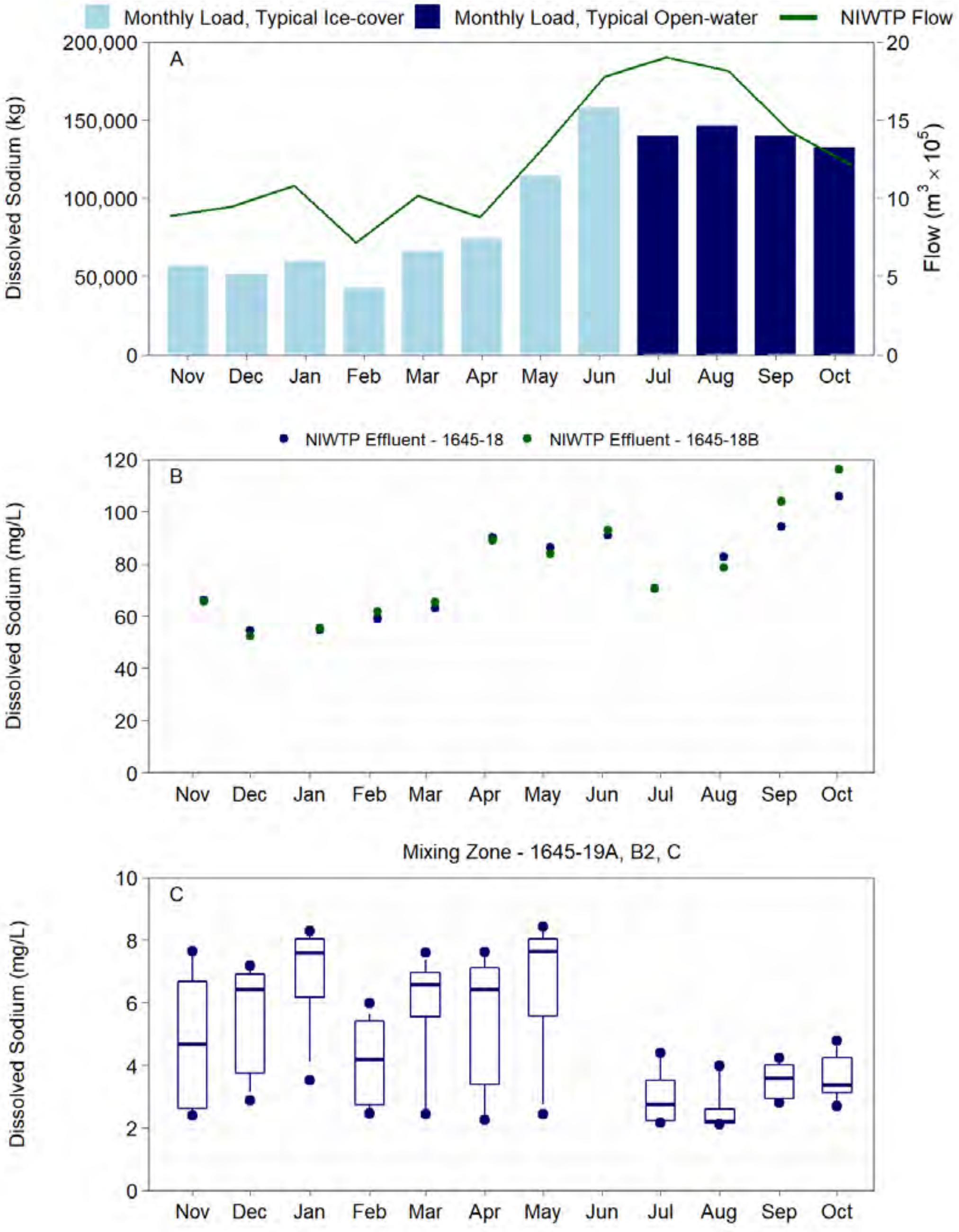
Figure 3-7 **Potassium (Dissolved): A) Monthly Loading Rate from the North Inlet Water Treatment Plant, B) Concentration in Effluent (SNP 1645-18 and SNP 1645-18B), and C) Concentration at the Mixing Zone Boundary (SNP 1645-19), 1 November 2019 to 31 October 2020**



Notes: Effluent values represent concentrations in individual samples. Mixing zone boxplots represent the 10th, 25th, 50th (median), 75th, and 90th percentile concentrations at three stations (i.e., 1645-19A, 1645-19B2, 1645-19C) and five depths (i.e., 2 m, 5 m, 10 m, 15 m, and 20 m); circles represent the 5th and 95th percentile concentrations. The mixing zone samples could not be collected in June 2020 due to unsafe ice conditions.

NIWTP = North Inlet Water Treatment Plant; SNP = Surveillance Network Program.

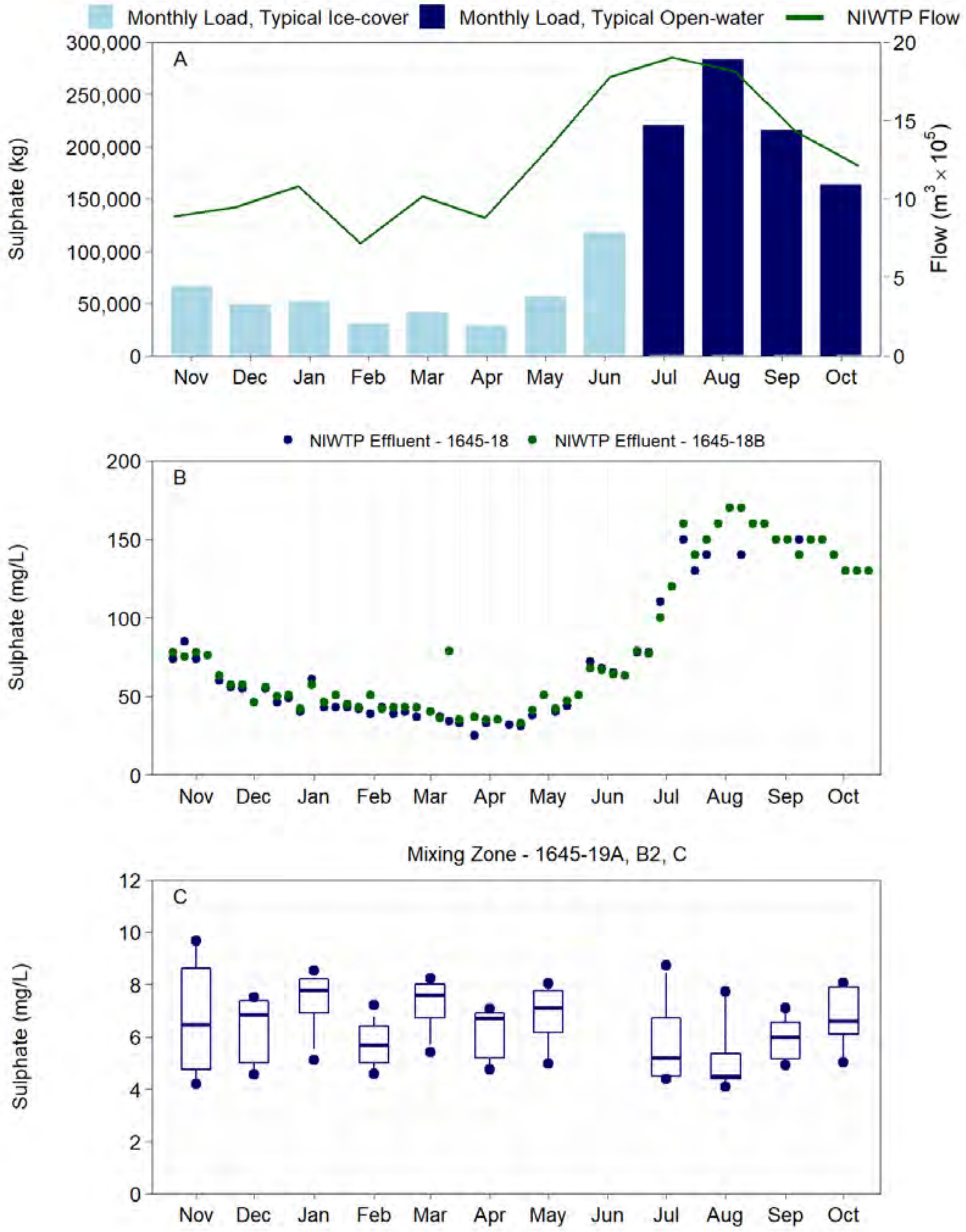
Figure 3-8 Sodium (Dissolved): A) Monthly Loading Rate from the North Inlet Water Treatment Plant, B) Concentration in Effluent (SNP 1645-18 and SNP 1645-18B), and C) Concentration at the Mixing Zone Boundary (SNP 1645-19), 1 November 2019 to 31 October 2020



Notes: Effluent values represent concentrations in individual samples. Mixing zone boxplots represent the 10th, 25th, 50th (median), 75th, and 90th percentile concentrations at three stations (i.e., 1645-19A, 1645-19B2, 1645-19C) and five depths (i.e., 2 m, 5 m, 10 m, 15 m, and 20 m); circles represent the 5th and 95th percentile concentrations. The mixing zone samples could not be collected in June 2020 due to unsafe ice conditions.

NIWTP = North Inlet Water Treatment Plant; SNP = Surveillance Network Program.

Figure 3-9 **Sulphate: A) Monthly Loading Rate from the North Inlet Water Treatment Plant, B) Concentration in Effluent (SNP 1645-18 and SNP 1645-18B), and C) Concentration at the Mixing Zone Boundary (SNP 1645-19), 1 November 2019 to 31 October 2020**



Notes: Effluent values represent concentrations in individual samples. Mixing zone boxplots represent the 10th, 25th, 50th (median), 75th, and 90th percentile concentrations at three stations (i.e., 1645-19A, 1645-19B2, 1645-19C) and five depths (i.e., 2 m, 5 m, 10 m, 15 m, and 20 m); circles represent the 5th and 95th percentile concentrations. The mixing zone samples could not be collected in June 2020 due to unsafe ice conditions.

NIWTP = North Inlet Water Treatment Plant; SNP = Surveillance Network Program.

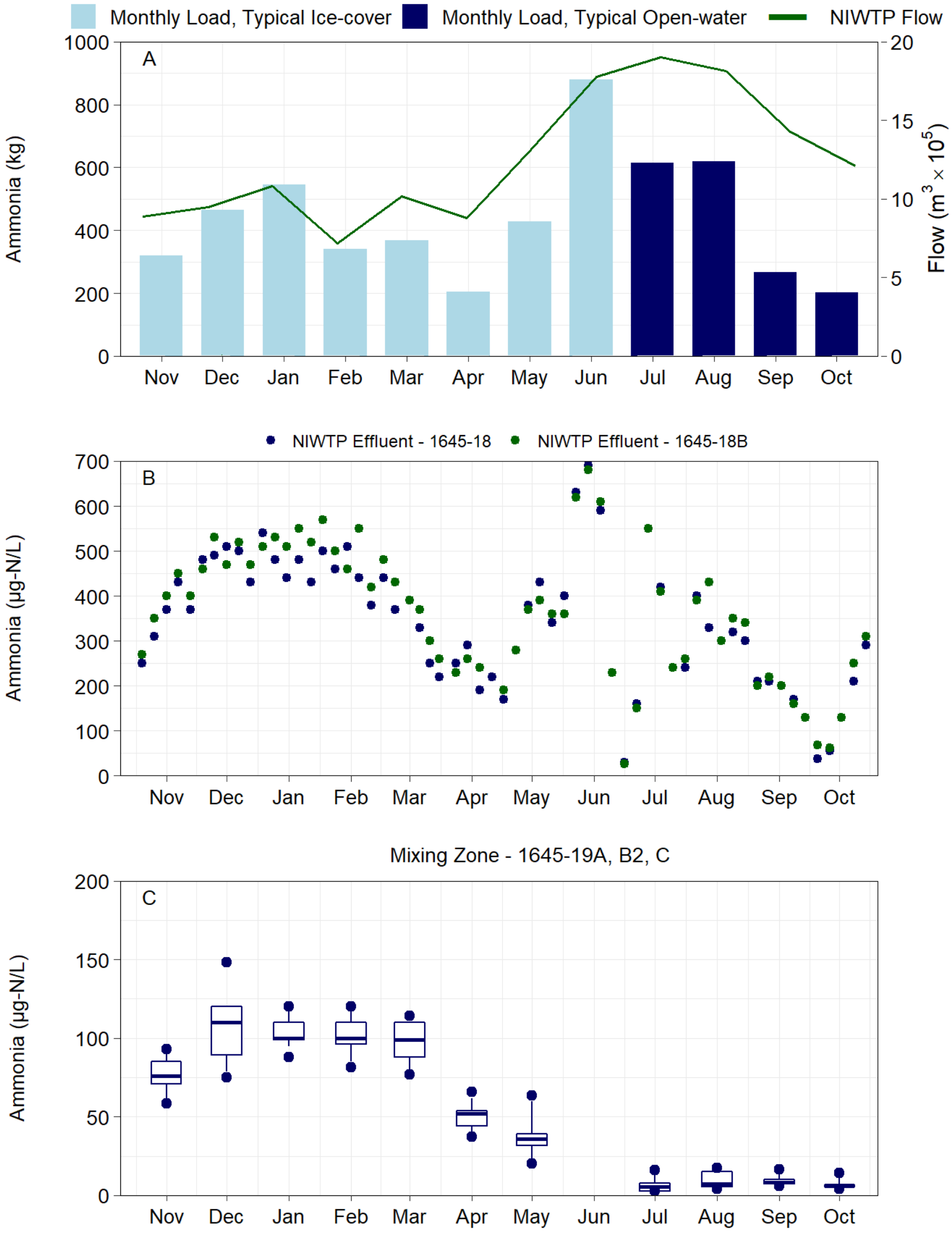
3.2.2 Nitrogen Variables

The nitrogen variables that met Criterion 3 in the SOI selection process (Section 2.4.1) included ammonia and nitrate. Loads of these variables, together with their concentrations in effluent and at the mixing zone boundary, are presented in Figure 3-10 and Figure 3-11.

The monthly loading rate of ammonia increased from November to January, decreased through April, and then increased again through late ice-cover before subsequently decreasing through the open-water season (Figure 3-10A/B). The seasonal trend in the loading rate of ammonia reflected trends both in the effluent flow rate and in effluent concentration. The load and concentration of nitrate generally declined through the early ice-cover season from November to April, and then increased through late ice-cover and early open-water, peaking in August, before decreasing again in September and October (Figure 3-11A/B).

The median concentrations of ammonia at the mixing zone boundary in the ice-cover season generally reflected trends in effluent concentration (Figure 3-10C). Concentrations of ammonia at the mixing zone boundary were lower and less variable in the open-water season compared to the ice-cover season. The median concentrations of nitrate generally remained within a similar range during the ice-cover season and then decreased in the early open-water season, with the lowest median value occurring in August. Median nitrate concentrations then increased in September and October (Figure 3-11C).

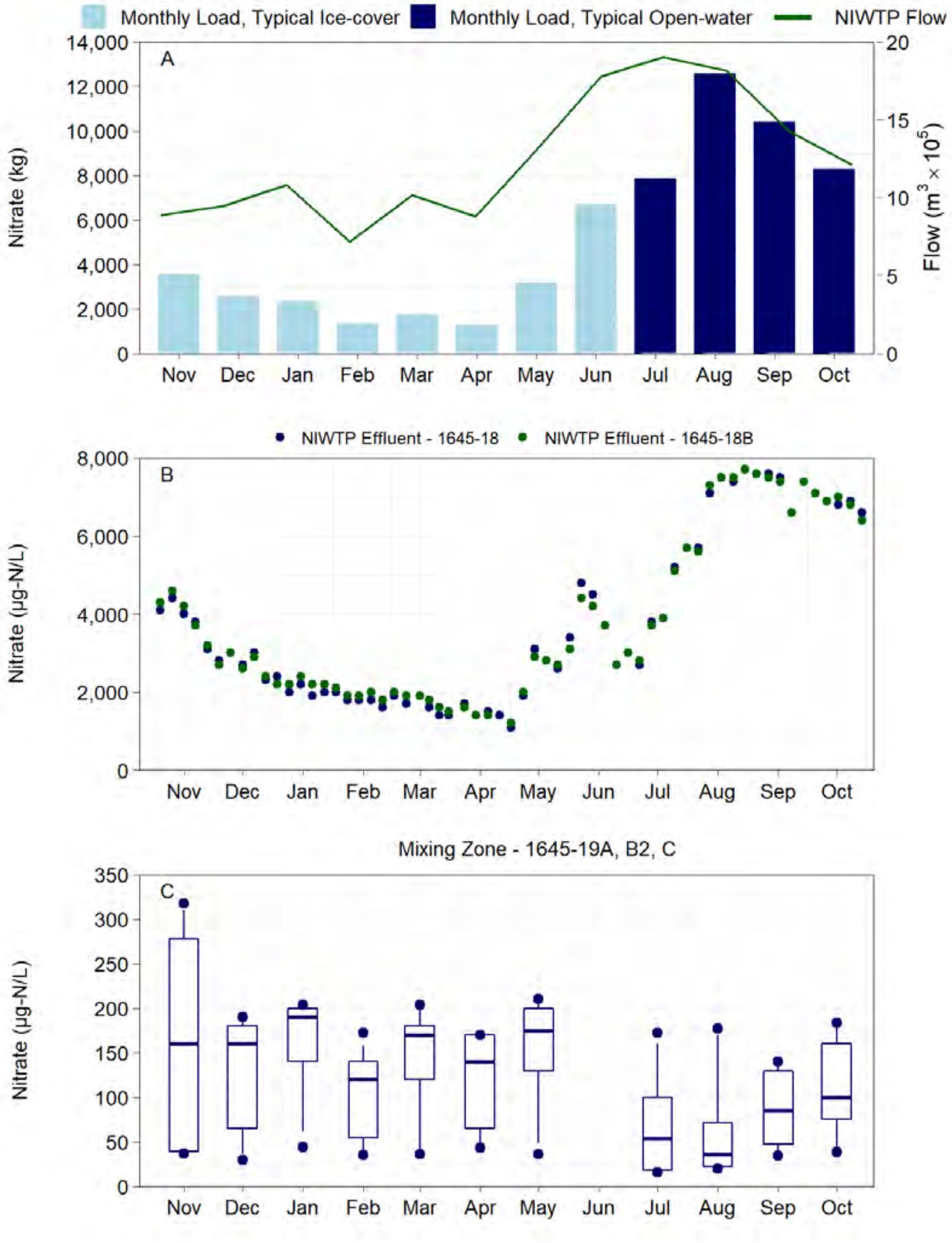
Figure 3-10 Ammonia: A) Monthly Loading Rate from the North Inlet Water Treatment Plant, B) Concentration in Effluent (SNP 1645-18 and SNP 1645-18B), and C) Concentration at the Mixing Zone Boundary (SNP 1645-19), 1 November 2019 to 31 October 2020



Notes: Effluent values represent concentrations in individual samples. Mixing zone boxplots represent the 10th, 25th, 50th (median), 75th, and 90th percentile concentrations at three stations (i.e., 1645-19A, 1645-19B2, 1645-19C) and five depths (i.e., 2 m, 5 m, 10 m, 15 m, and 20 m); circles represent the 5th and 95th percentile concentrations. The mixing zone samples could not be collected in June 2020 due to unsafe ice conditions.

NIWTP = North Inlet Water Treatment Plant; SNP = Surveillance Network Program.

Figure 3-11 Nitrate: A) Monthly Loading Rate from the North Inlet Water Treatment Plant, B) Concentration in Effluent (SNP 1645-18 and SNP 1645-18B), and C) Concentration at the Mixing Zone Boundary (SNP 1645-19), 1 November 2019 to 31 October 2020



Notes: Effluent values represent concentrations in individual samples. Mixing zone boxplots represent the 10th, 25th, 50th (median), 75th, and 90th percentile concentrations at three stations (i.e., 1645-19A, 1645-19B2, 1645-19C) and five depths (i.e., 2 m, 5 m, 10 m, 15 m, and 20 m); circles represent the 5th and 95th percentile concentrations. The mixing zone samples could not be collected in June 2020 due to unsafe ice conditions.

NIWTP = North Inlet Water Treatment Plant; SNP = Surveillance Network Program.

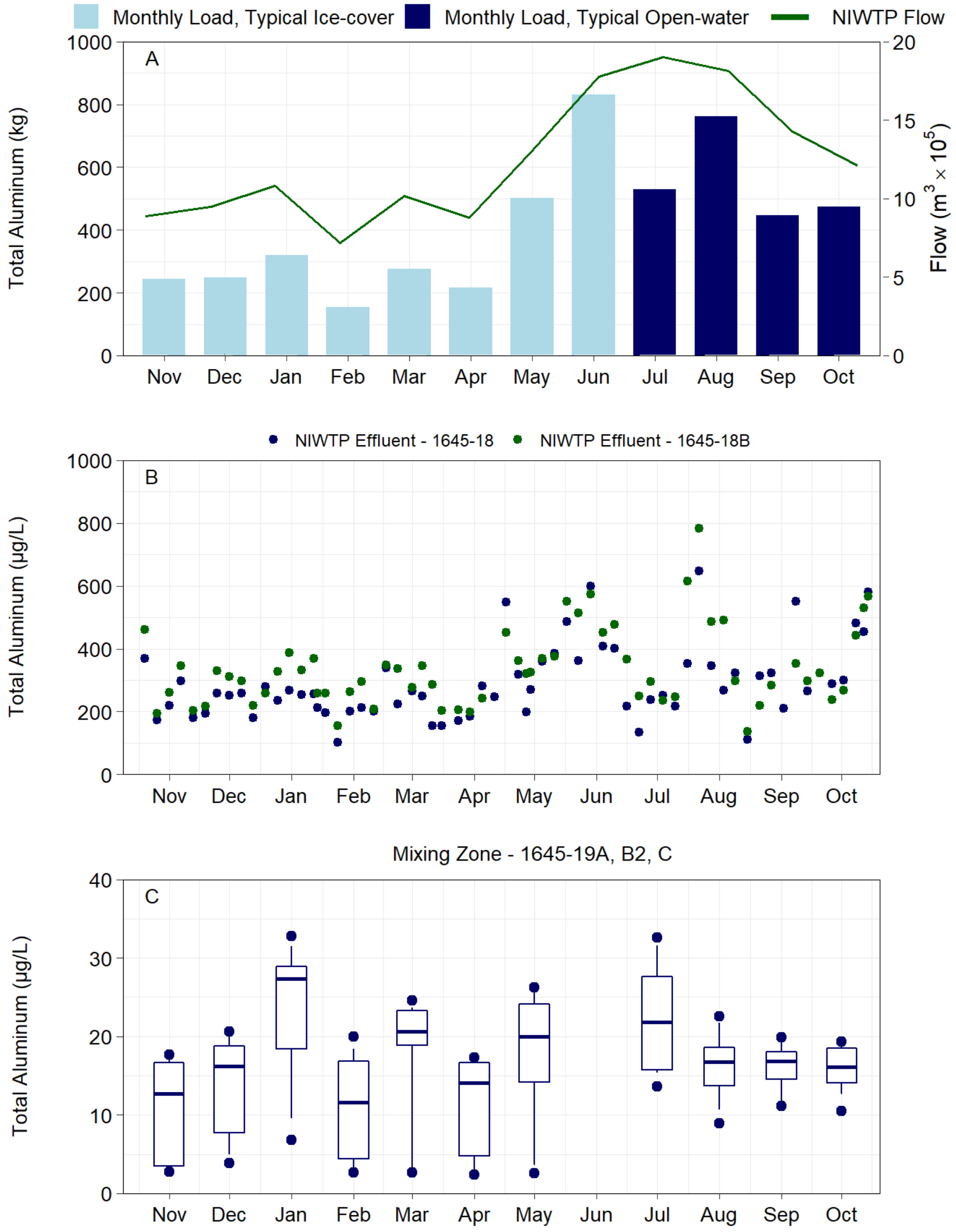
3.2.3 Total Metals

The total metal SOIs that met Criterion 3 in the SOI selection process (Section 2.4.1) included aluminum, antimony, barium, chromium, copper, molybdenum, silicon, strontium, sulphur, and uranium. Loads of these variables, together with their concentrations in effluent and at the mixing zone boundary, are presented in Figure 3-12 to Figure 3-21. The monthly loading rates of total metal SOIs either reflected trends in the effluent flow rate or chemistry, or were influenced by a combination of the two. The seasonal pattern in the concentrations of variables in the effluent over the reporting period were variable-specific:

- The concentration of aluminum generally remained within a similar range throughout the reporting period, with the exception of June, early August, and late October when concentrations increased (Figure 3-12B).
- The concentration of antimony decreased from November to January, remained within a similar range through May, and then generally increased through the remainder of the reporting period (Figure 3-13B).
- The concentration of barium in effluent decreased through November, remained within a similar range through March, increased in April before decreasing through June, and subsequently increased through the open-water season (Figure 3-14B).
- The concentration of chromium in effluent increased through February and subsequently decreased through the remainder of the reporting period (Figure 3-15B).
- The concentration of copper gradually decreased through April, increased through the late ice-cover and early open-water season, peaking in August, before subsequently decreasing through the remainder of the reporting period (Figure 3-16B).
- The concentrations of molybdenum and sulphur in effluent decreased gradually from November to January, remained within a similar range through April, then increased and became more variable during the open-water season (Figure 3-17B).
- The concentration of silicon in effluent increased gradually from November to April, decreased in late ice-cover, and subsequently remained within a similar range for the remainder of the reporting period (Figure 3-18B).
- The concentration of strontium remained within a similar range through March, increased in April, and then decreased through June before subsequently increasing through the open-water season (Figure 3-19B).
- The concentration of uranium in effluent remained within a similar range through the ice-cover season, decreased in June before increasing through August, and then decreased through the remainder of the reporting period (Figure 3-21B).

Concentrations of most total metal SOIs in the effluent were greater than the concentrations measured at the mixing zone boundary in 2020, indicating that the Mine effluent is a source of these constituents to Lac de Gras. One exception was copper, which had generally similar or lower concentrations in the effluent than those recorded at the mixing zone boundary, with the exception of a short period in August (Figure 3-16B/C). The concentrations of most of these SOIs at the mixing zone boundary were generally greater and more variable during the ice-cover season than during the open-water season (Figure 3-12C to Figure 3-21C).

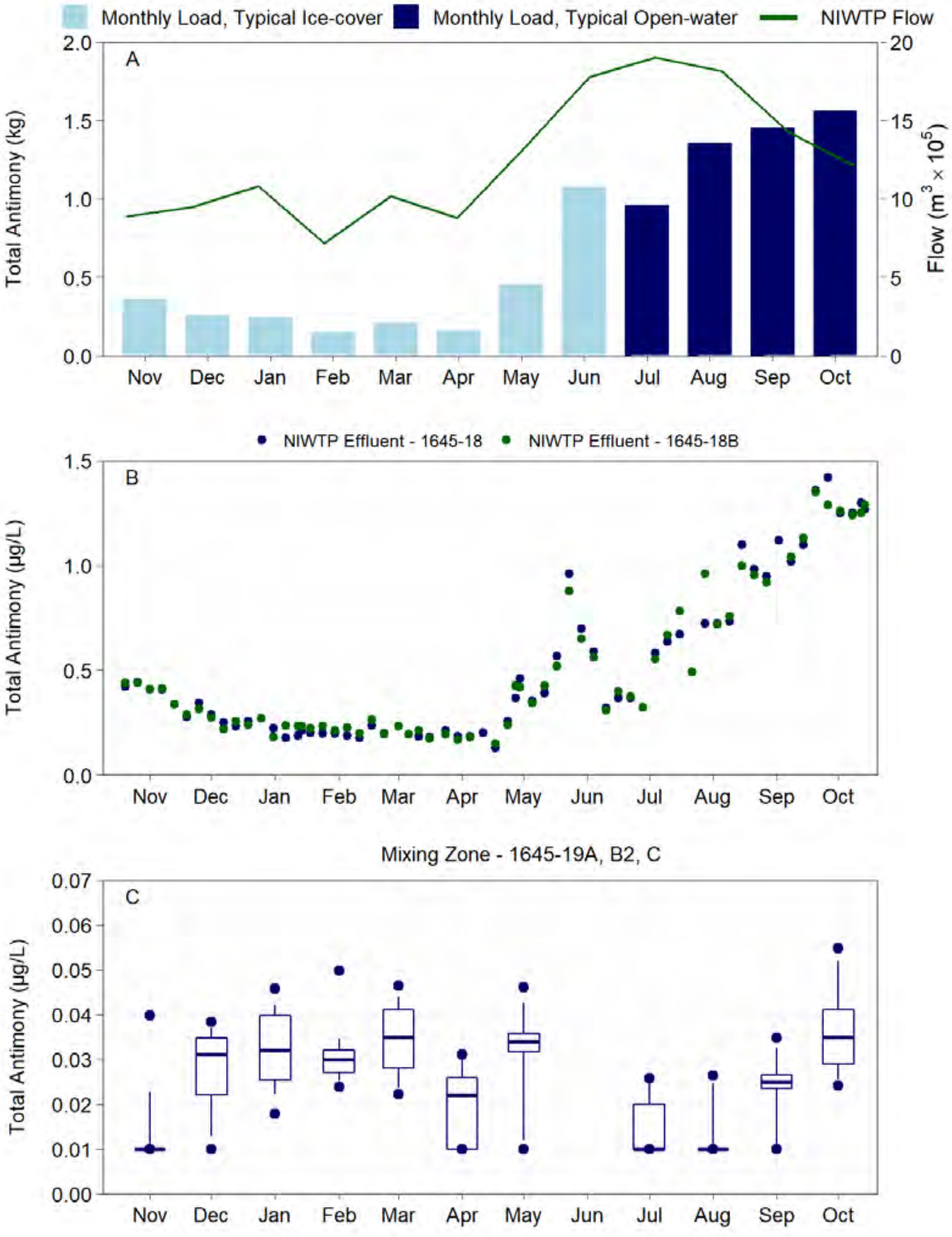
Figure 3-12 Aluminum: A) Monthly Loading Rate from the North Inlet Water Treatment Plant, B) Concentration in Effluent (SNP 1645-18 and SNP 1645-18B), and C) Concentration at the Mixing Zone Boundary (SNP 1645-19), 1 November 2019 to 31 October 2020



Notes: Effluent values represent concentrations in individual samples. Mixing zone boxplots represent the 10th, 25th, 50th (median), 75th, and 90th percentile concentrations at three stations (i.e., 1645-19A, 1645-19B2, 1645-19C) and five depths (i.e., 2 m, 5 m, 10 m, 15 m, and 20 m); circles represent the 5th and 95th percentile concentrations. The mixing zone samples could not be collected in June 2020 due to unsafe ice conditions.

NIWTP = North Inlet Water Treatment Plant; SNP = Surveillance Network Program.

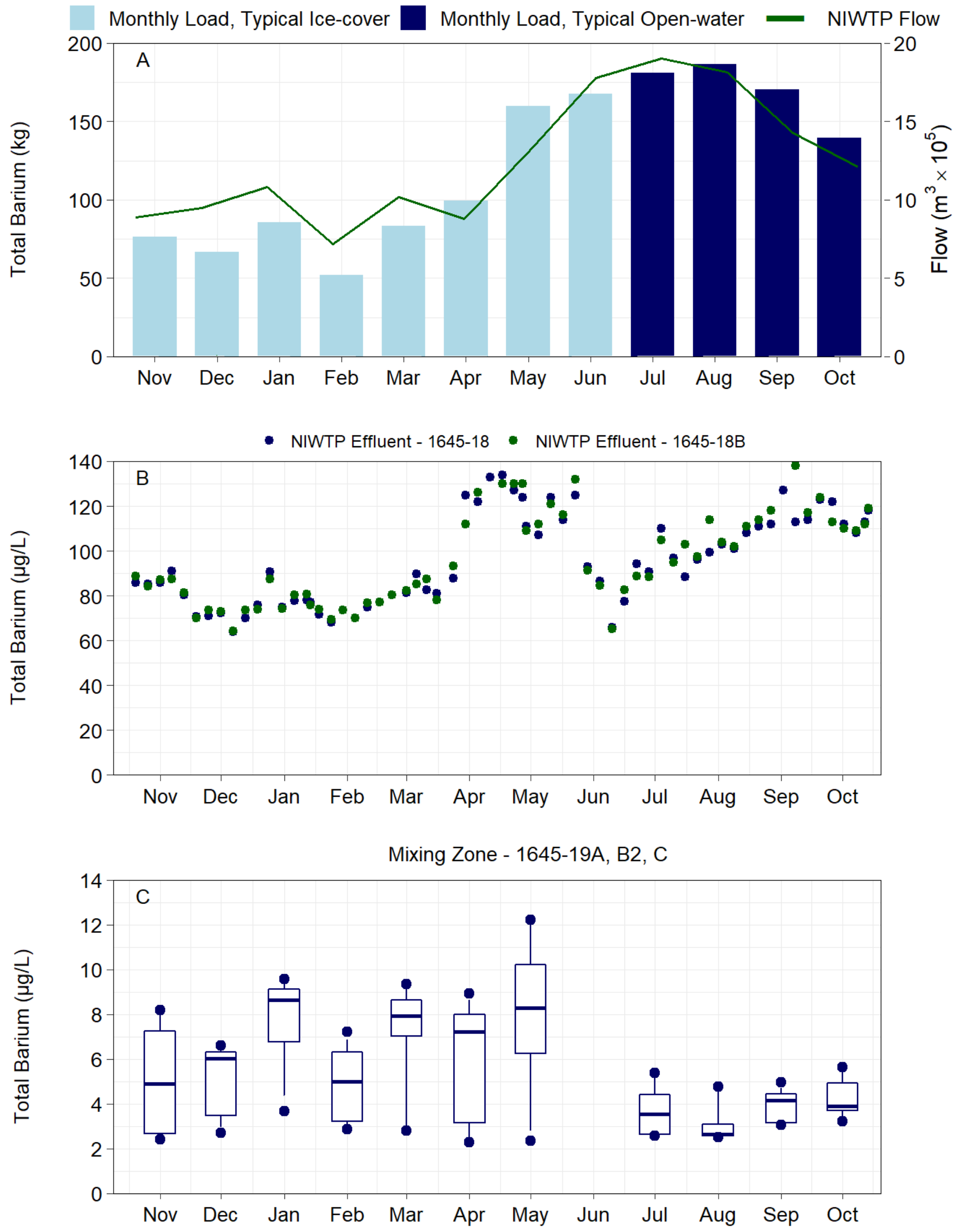
Figure 3-13 Antimony: A) Monthly Loading Rate from the North Inlet Water Treatment Plant, B) Concentration in Effluent (SNP 1645-18 and SNP 1645-18B), and C) Concentration at the Mixing Zone Boundary (SNP 1645-19), 1 November 2019 to 31 October 2020



Notes: Effluent values represent concentrations in individual samples. Mixing zone boxplots represent the 10th, 25th, 50th (median), 75th, and 90th percentile concentrations at three stations (i.e., 1645-19A, 1645-19B2, 1645-19C) and five depths (i.e., 2 m, 5 m, 10 m, 15 m, and 20 m); circles represent the 5th and 95th percentile concentrations. The mixing zone samples could not be collected in June 2020 due to unsafe ice conditions.

NIWTP = North Inlet Water Treatment Plant; SNP = Surveillance Network Program.

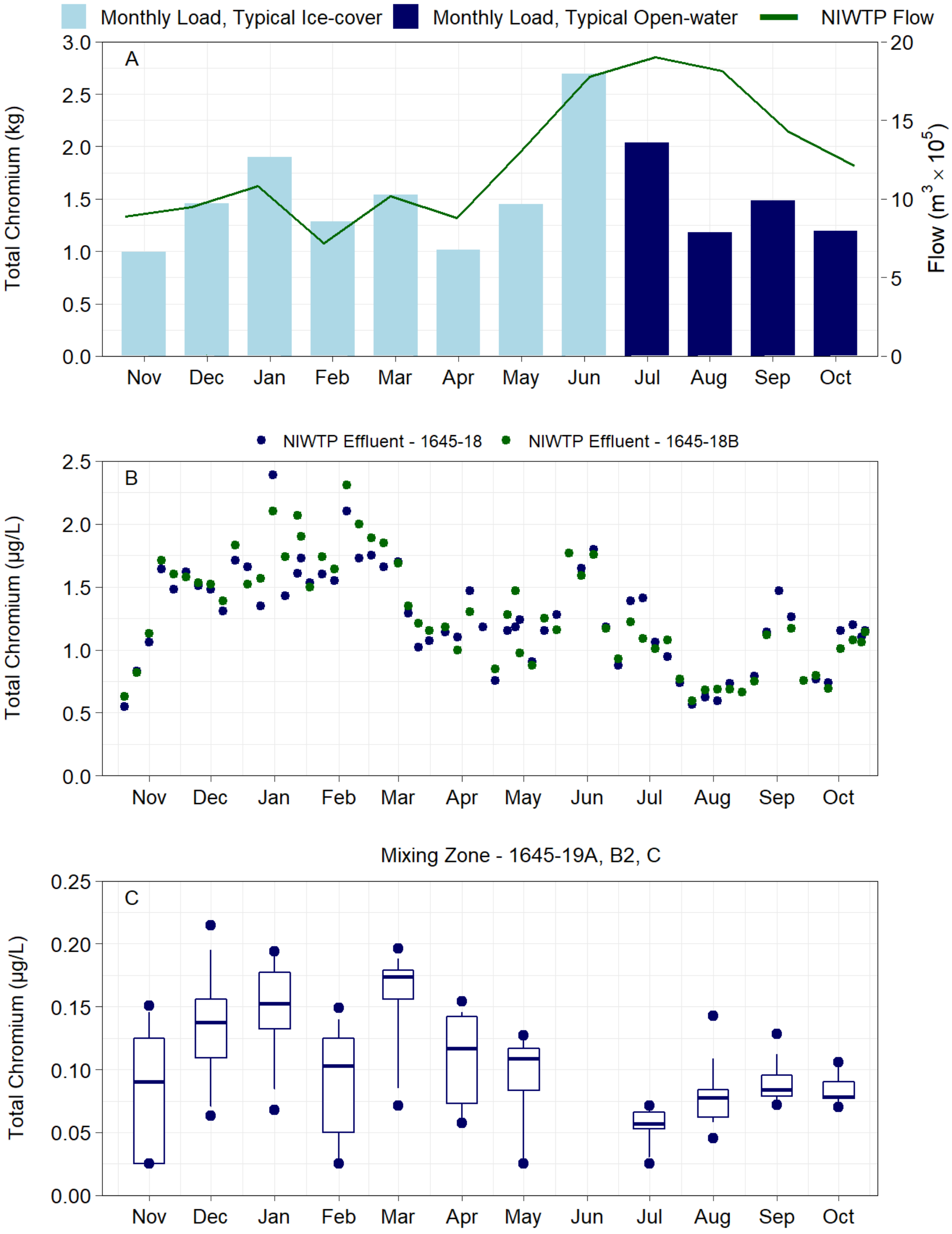
Figure 3-14 **Barium: A) Monthly Loading Rate from the North Inlet Water Treatment Plant, B) Concentration in Effluent (SNP 1645-18 and SNP 1645-18B), and C) Concentration at the Mixing Zone Boundary (SNP 1645-19), 1 November 2019 to 31 October 2020**



Notes: Effluent values represent concentrations in individual samples. Mixing zone boxplots represent the 10th, 25th, 50th (median), 75th, and 90th percentile concentrations at three stations (i.e., 1645-19A, 1645-19B2, 1645-19C) and five depths (i.e., 2 m, 5 m, 10 m, 15 m, and 20 m); circles represent the 5th and 95th percentile concentrations. The mixing zone samples could not be collected in June 2020 due to unsafe ice conditions.

NIWTP = North Inlet Water Treatment Plant; SNP = Surveillance Network Program.

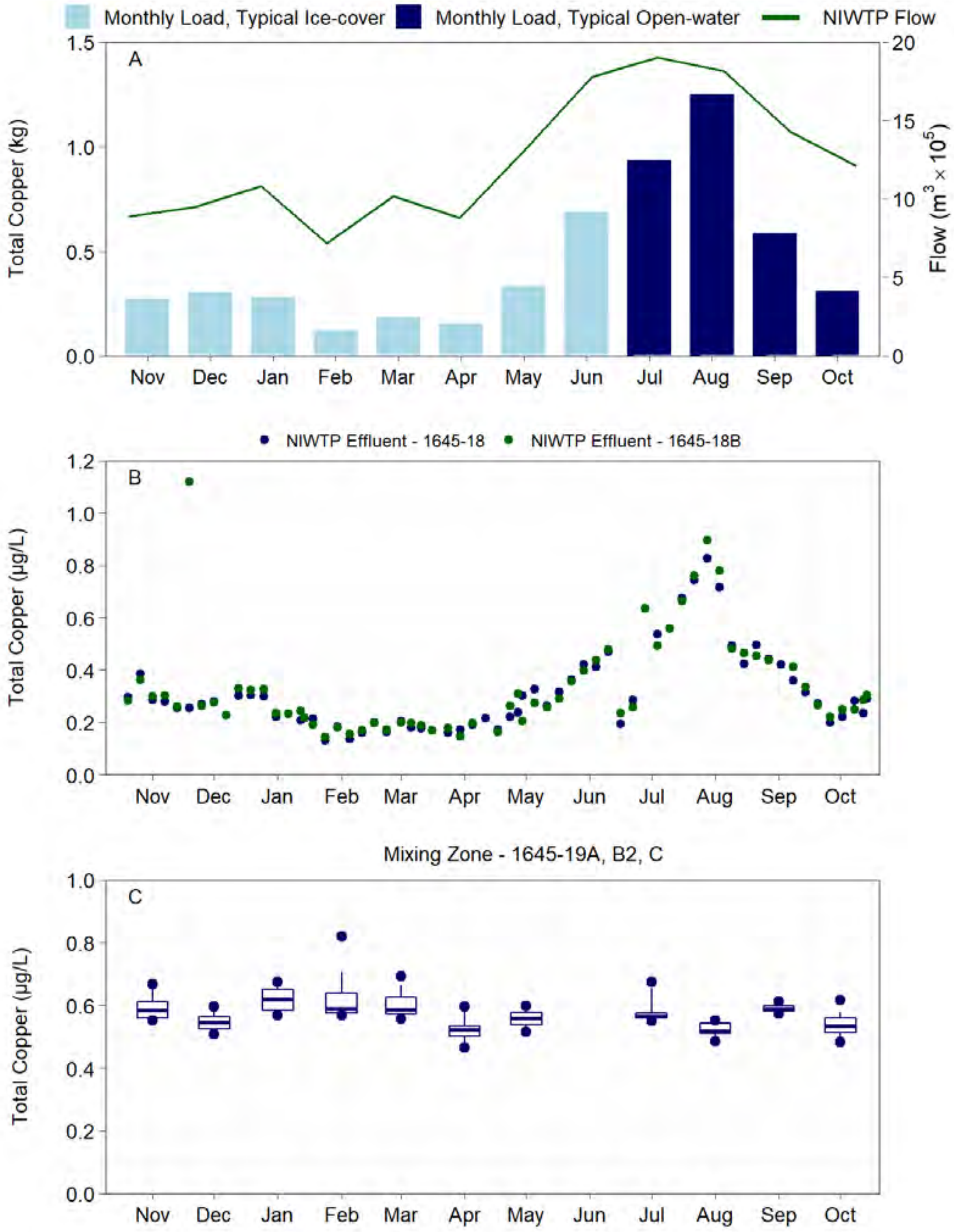
Figure 3-15 **Chromium: A) Monthly Loading Rate from the North Inlet Water Treatment Plant, B) Concentration in Effluent (SNP 1645-18 and SNP 1645-18B), and C) Concentration at the Mixing Zone Boundary (SNP 1645-19), 1 November 2019 to 31 October 2020**



Notes: Effluent values represent concentrations in individual samples. Mixing zone boxplots represent the 10th, 25th, 50th (median), 75th, and 90th percentile concentrations at three stations (i.e., 1645-19A, 1645-19B2, 1645-19C) and five depths (i.e., 2 m, 5 m, 10 m, 15 m, and 20 m); circles represent the 5th and 95th percentile concentrations. The mixing zone samples could not be collected in June 2020 due to unsafe ice conditions.

NIWTP = North Inlet Water Treatment Plant; SNP = Surveillance Network Program.

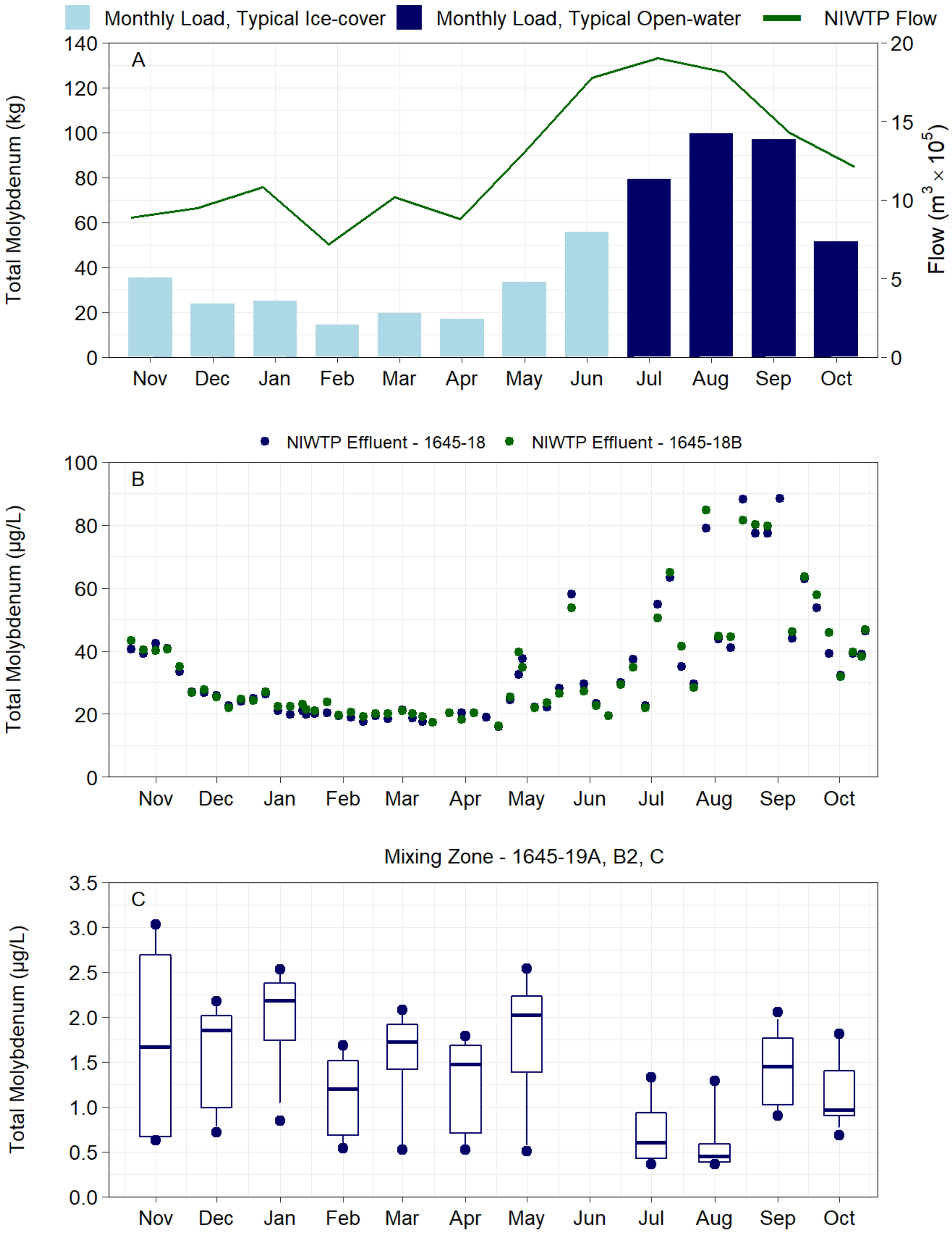
Figure 3-16 **Copper: A) Monthly Loading Rate from the North Inlet Water Treatment Plant, B) Concentration in Effluent (SNP 1645-18 and SNP 1645-18B), and C) Concentration at the Mixing Zone Boundary (SNP 1645-19), 1 November 2019 to 31 October 2020**



Notes: Effluent values represent concentrations in individual samples. Mixing zone boxplots represent the 10th, 25th, 50th (median), 75th, and 90th percentile concentrations at three stations (i.e., 1645-19A, 1645-19B2, 1645-19C) and five depths (i.e., 2 m, 5 m, 10 m, 15 m, and 20 m); circles represent the 5th and 95th percentile concentrations. The mixing zone samples could not be collected in June 2020 due to unsafe ice conditions.

NIWTP = North Inlet Water Treatment Plant; SNP = Surveillance Network Program.

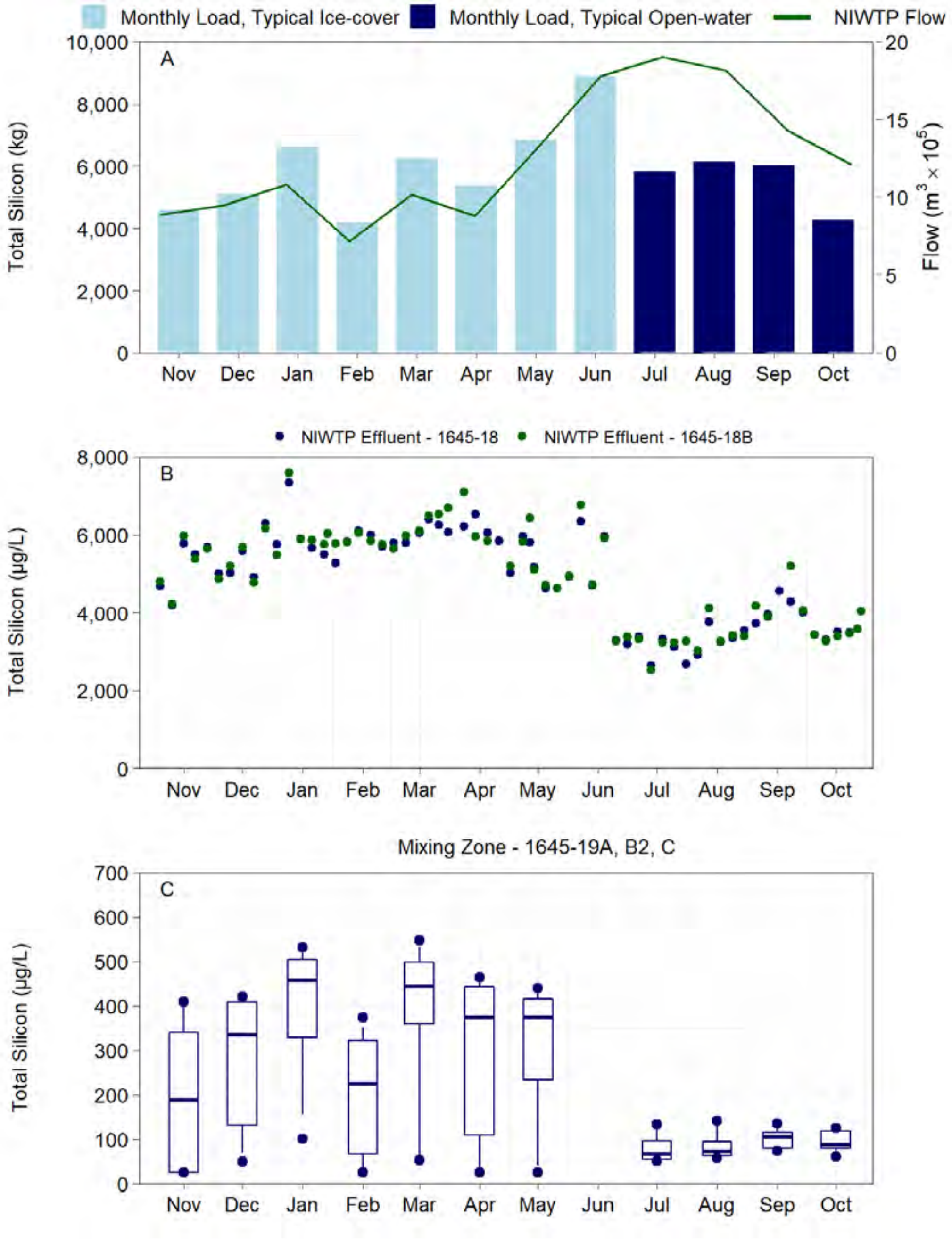
Figure 3-17 **Molybdenum: A) Monthly Loading Rate from the North Inlet Water Treatment Plant, B) Concentration in Effluent (SNP 1645-18 and SNP 1645-18B), and C) Concentration at the Mixing Zone Boundary (SNP 1645-19), 1 November 2019 to 31 October 2020**



Notes: Effluent values represent concentrations in individual samples. Mixing zone boxplots represent the 10th, 25th, 50th (median), 75th, and 90th percentile concentrations at three stations (i.e., 1645-19A, 1645-19B2, 1645-19C) and five depths (i.e., 2 m, 5 m, 10 m, 15 m, and 20 m); circles represent the 5th and 95th percentile concentrations. The mixing zone samples could not be collected in June 2020 due to unsafe ice conditions.

NIWTP = North Inlet Water Treatment Plant; SNP = Surveillance Network Program.

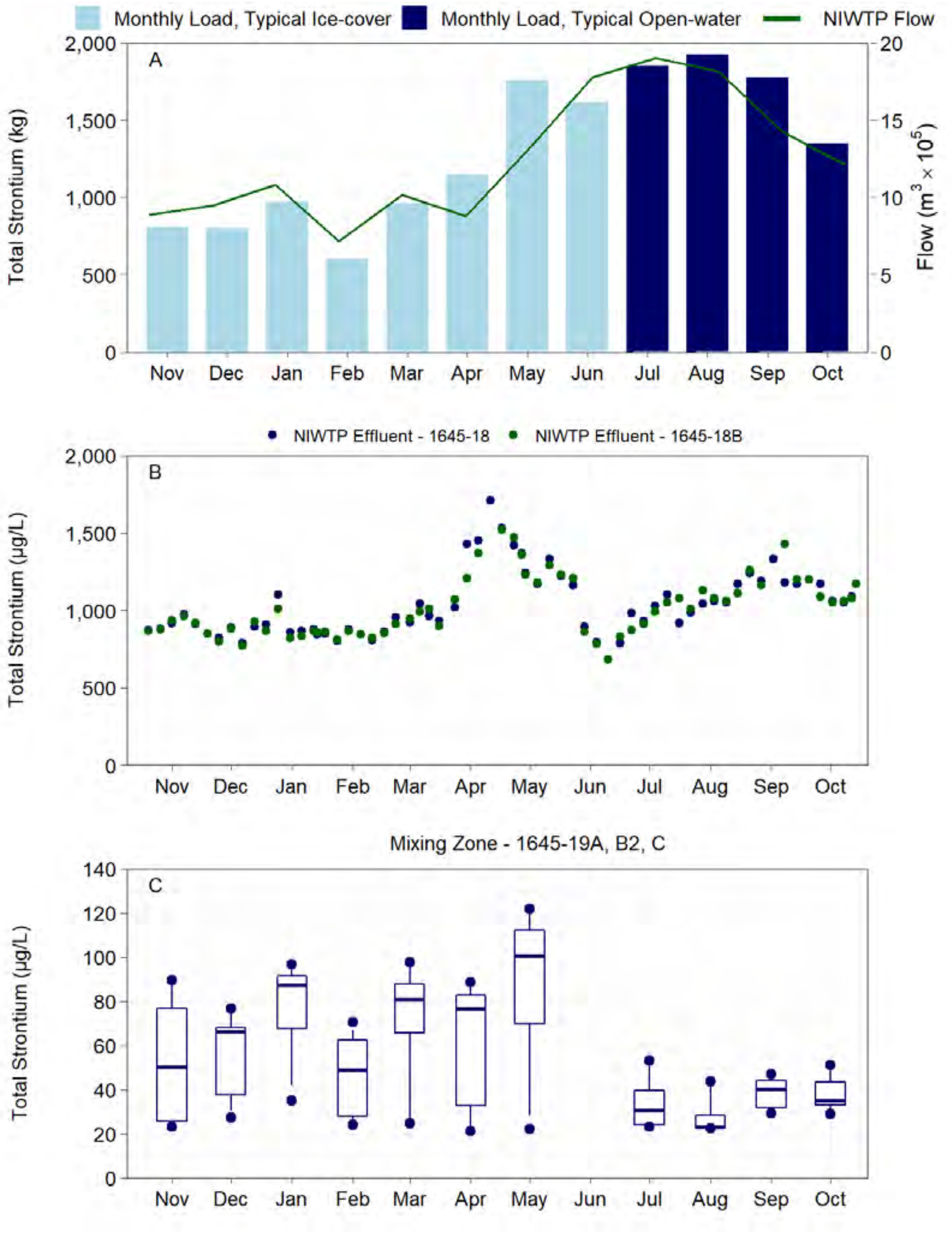
Figure 3-18 Silicon: A) Monthly Loading Rate from the North Inlet Water Treatment Plant, B) Concentration in Effluent (SNP 1645-18 and SNP 1645-18B), and C) Concentration at the Mixing Zone Boundary (SNP 1645-19), 1 November 2019 to 31 October 2020



Notes: Effluent values represent concentrations in individual samples. Mixing zone boxplots represent the 10th, 25th, 50th (median), 75th, and 90th percentile concentrations at three stations (i.e., 1645-19A, 1645-19B2, 1645-19C) and five depths (i.e., 2 m, 5 m, 10 m, 15 m, and 20 m); circles represent the 5th and 95th percentile concentrations. The mixing zone samples could not be collected in June 2020 due to unsafe ice conditions.

NIWTP = North Inlet Water Treatment Plant; SNP = Surveillance Network Program.

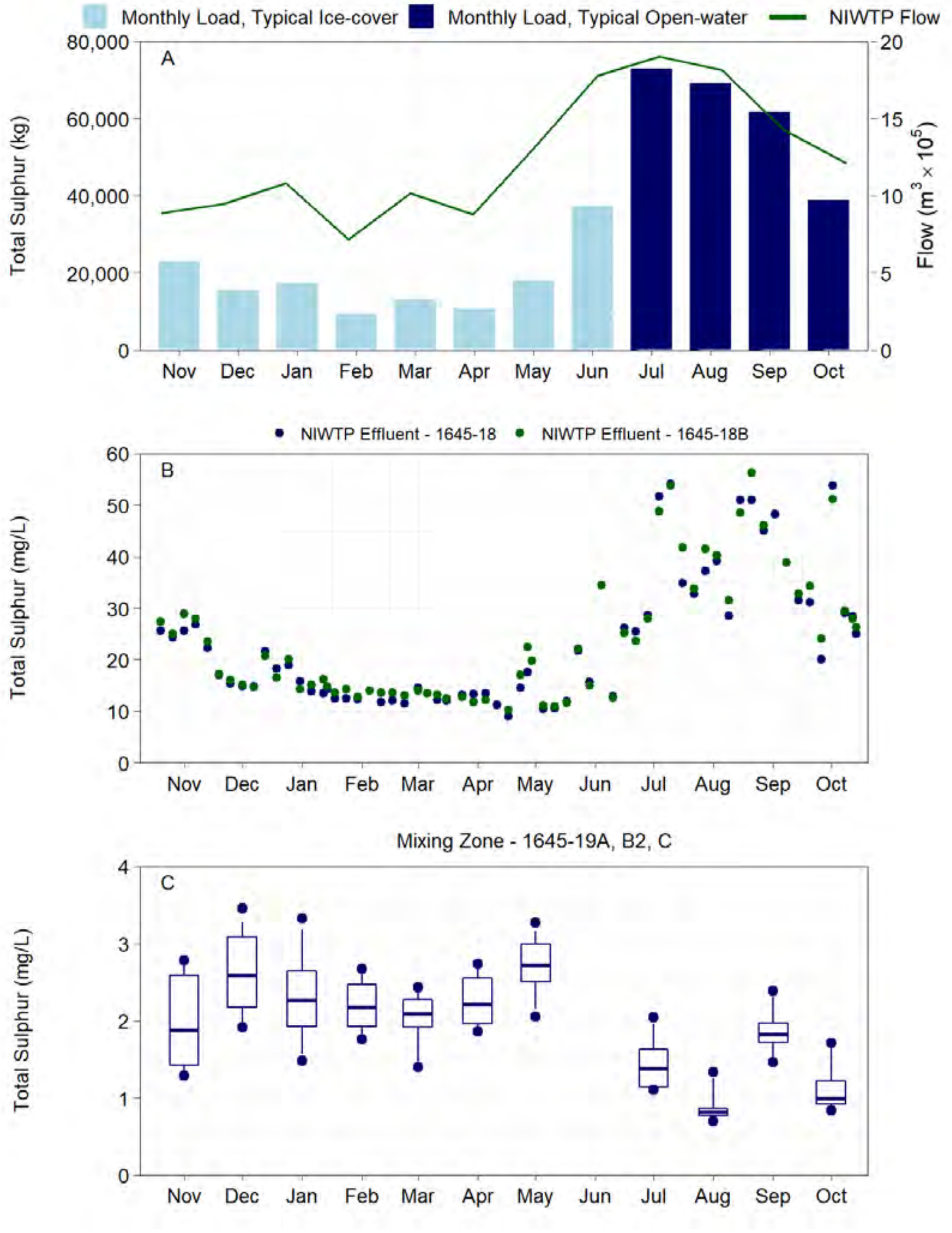
Figure 3-19 **Strontium: A) Monthly Loading Rate from the North Inlet Water Treatment Plant, B) Concentration in Effluent (SNP 1645-18 and SNP 1645-18B), and C) Concentration at the Mixing Zone Boundary (SNP 1645-19), 1 November 2019 to 31 October 2020**



Notes: Effluent values represent concentrations in individual samples. Mixing zone boxplots represent the 10th, 25th, 50th (median), 75th, and 90th percentile concentrations at three stations (i.e., 1645-19A, 1645-19B2, 1645-19C) and five depths (i.e., 2 m, 5 m, 10 m, 15 m, and 20 m); circles represent the 5th and 95th percentile concentrations. The mixing zone samples could not be collected in June 2020 due to unsafe ice conditions.

NIWTP = North Inlet Water Treatment Plant; SNP = Surveillance Network Program.

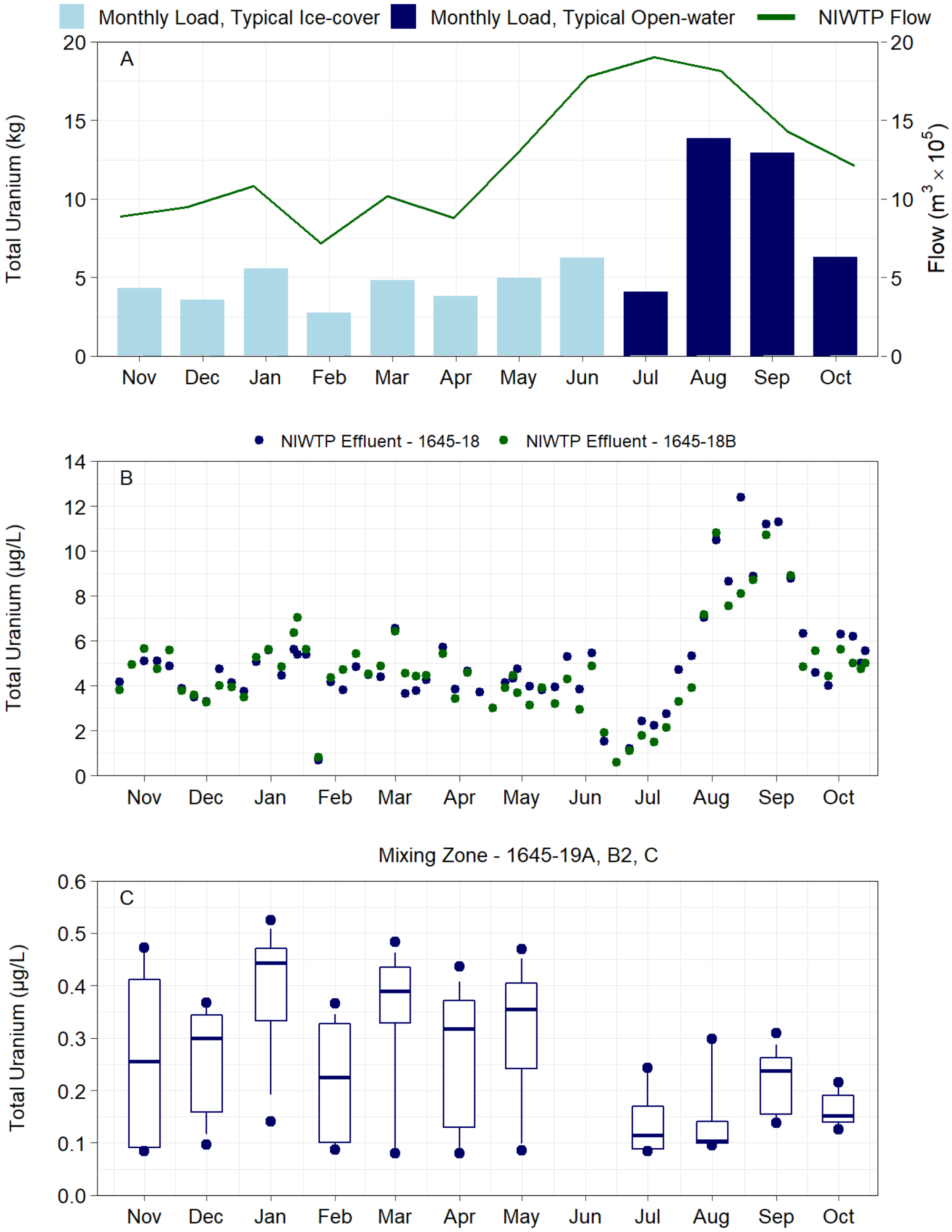
Figure 3-20 **Sulphur: A) Monthly Loading Rate from the North Inlet Water Treatment Plant, B) Concentration in Effluent (SNP 1645-18 and SNP 1645-18B), and C) Concentration at the Mixing Zone Boundary (SNP 1645-19), 1 November 2019 to 31 October 2020**



Notes: Effluent values represent concentrations in individual samples. Mixing zone boxplots represent the 10th, 25th, 50th (median), 75th, and 90th percentile concentrations at three stations (i.e., 1645-19A, 1645-19B2, 1645-19C) and five depths (i.e., 2 m, 5 m, 10 m, 15 m, and 20 m); circles represent the 5th and 95th percentile concentrations. The mixing zone samples could not be collected in June 2020 due to unsafe ice conditions.

NIWTP = North Inlet Water Treatment Plant; SNP = Surveillance Network Program.

Figure 3-21 **Uranium: A) Monthly Loading Rate from the North Inlet Water Treatment Plant, B) Concentration in Effluent (SNP 1645-18 and SNP 1645-18B), and C) Concentration at the Mixing Zone Boundary (SNP 1645-19), 1 November 2019 to 31 October 2020**



Notes: Effluent values represent concentrations in individual samples. Mixing zone boxplots represent the 10th, 25th, 50th (median), 75th, and 90th percentile concentrations at three stations (i.e., 1645-19A, 1645-19B2, 1645-19C) and five depths (i.e., 2 m, 5 m, 10 m, 15 m, and 20 m); circles represent the 5th and 95th percentile concentrations. The mixing zone samples could not be collected in June 2020 due to unsafe ice conditions.

NIWTP = North Inlet Water Treatment Plant; SNP = Surveillance Network Program.

3.2.4 Comparison to Effluent Quality Criteria

During the 2020 sampling period, concentrations of variables in effluent with EQC were below the maximum allowable concentration in any grab sample. Similarly, the average concentrations were below EQC for the Maximum Average Concentration at both diffusers (Table 3-2). Therefore, no variables triggered Criterion 1 in the SOI selection process (Section 2.4.1).

In addition to the criteria listed in Table 3-2, all discharges from the NIWTP in 2020 to Lac de Gras had pH values between 6.0 to 8.4 (range: 6.3 to 8.1; median: 7.3), per Water Licence requirements (WLWB 2015). The monthly SNP reports submitted to the WLWB provide graphs demonstrating compliance of effluent chemistry with EQCs. These reports are accessible on the WLWB public registry.

3.2.5 Comparison of Mixing Zone Data to Effects Benchmarks

During the 2020 sampling period, nearly all concentrations measured in samples collected at the mixing zone boundary were within the relevant AEMP water quality Effects Benchmarks for the protection of aquatic life and drinking water (Table 3-3). The total copper sample at SNP 1645-19A collected on 29 February 2020 (3.11 µg/L) and TSS sample at SNP 1645-19A collected on 13 May 2020 (8.7 mg/L), exceeded the Effects Benchmarks of 2 µg/L and 5 mg/L, respectively. The dissolved copper concentration associated with the same sample was well below the Effects Benchmark (0.535 µg/L), indicating that the total copper value was likely erroneous. Both the total copper and TSS values were identified as anomalous values during the initial data screening (Section 2.3.2), indicating that they were extreme values compared to other samples collected at the mixing zone boundary. All other total copper and TSS values were below the Effects Benchmarks. Consequently, total copper and TSS did not trigger Criterion 2 in the SOI selection process (Section 2.4.1).

None of the pH values measured at the mixing zone boundary in 2020 exceeded the upper limits of the aquatic life and drinking water Effects Benchmarks (i.e., 8.5 and 10.5, respectively). However, pH values measured at the mixing zone boundary in 2020, were below the drinking water Effects Benchmark value of 7.0 in 76% of samples and below the aquatic life Effects Benchmark value of 6.5 in 32% of samples (Table 3-3). Because the pH of the Mine effluent was slightly alkaline (i.e., median pH of 7.3) and the pH throughout Lac de Gras was often below the aquatic life Effects Benchmark of 6.5, during both ice-cover and open-water conditions at various depths, and over time (i.e., 2002 to 2019; Golder 2020b), these exceedances were attributed to natural conditions and unrelated to the Mine discharge. Therefore, pH did not trigger Criterion 2 in the SOI selection process (Section 2.4.1) and was not considered an SOI.

Table 3-2 Comparison of Effluent Chemistry to Effluent Quality Criteria, 1 November 2019 to 31 October 2020

Variable	Units	Effluent Quality Criteria		Effluent Concentration		
		Maximum Average Concentration	Maximum Concentration of Any Grab Sample	Minimum	Maximum	Median
Total ammonia	µg-N/L	6,000	12,000	26	690	370
Total aluminum	µg/L	1,500	3,000	103	783	284
Total arsenic	µg/L	50	100	0.41	2.2	1.3
Total copper	µg/L	20	40	0.13	1.61	0.27
Total cadmium	µg/L	1.5	3	<0.005	0.013	<0.005
Total chromium	µg/L	20	40	0.55	2.4	1.2
Total lead	µg/L	10	20	<0.005	0.051	0.0051
Total nickel	µg/L	50	100	1.85	18.2	3.5
Total zinc	µg/L	10	20	<0.1	6.9	0.19
Nitrite	µg-N/L	1,000	2,000	<1.0	370	100
Total suspended solids	mg/L	15	25	<1.0	5.7	1.6
Turbidity	NTU	10	15	<0.1	1.6	0.3
Biochemical oxygen demand	mg/L	15	25	<2.0	2.6	<2.0
Total petroleum hydrocarbons	mg/L	3	5	<0.26	0.47	0.13
Fecal coliforms	CFU/100 mL	10	20	<1.0	<1.0	<1.0

µg-N/L = micrograms nitrogen per litre; NTU = nephelometric turbidity unit; CFU = colony forming units.

Table 3-3 Comparison of Mixing Zone Water Chemistry to AEMP Effects Benchmarks, 1 November 2019 to 31 October 2020

Variable	Unit	Effects Benchmarks		Mixing Zone Concentration		
		Protection of Aquatic Life	Drinking Water	Minimum	Maximum	Median
Conventional Parameters						
Dissolved oxygen – DDMI Labs	mg/L	6.5(a)	-	11.1	17.6	14.2
pH – BV Labs	pH Units	6.5 to 9.0	7.0 to 10.5	**5.1**	8.0	**6.6**
pH – DDMI Labs	pH Units	6.5 to 9.0	7.0 to 10.5	**6.2**	7.6	**6.7**
Total dissolved solids, calculated	mg/L	500	500	14	50	29
Total dissolved solids, measured	mg/L	500	500	<1.0	61	35
Total suspended solids	mg/L	+5 (24 h to 30 days) +25 (24 h period)	-	<1	**8.7**(c)	<1.0
Turbidity – lab	NTU	2.2 (long term, IC) 2.3 (long term, OW)	-	<0.1	0.72	0.14
Major Ions						
Calcium (dissolved)	mg/L	60	-	1.7	5.5	2.8
Chloride	mg/L	120	250	3.0	21	7.3
Fluoride	mg/L	0.12	1.5	0.025	0.042	0.032
Sodium (dissolved)	mg/L	52	200	2.1	8.6	4.2
Sulphate	mg/L	100	500	3.9	9.8	6.6
Nutrients						
Ammonia	µg/L	4,730	-	<5	200	53.5
Nitrate	µg/L	3,000	10,000	15	330	130
Nitrite	µg/L	60	1,000	<1	13	3
Total Metals						
Aluminum (total)	µg/L	87	100/200	2.3	33.7	16.9
Aluminum (dissolved)	µg/L	50(b)	-	1.2	25.9	10.8
Antimony	µg/L	33	6	<0.02	0.072	0.026
Arsenic	µg/L	5	10	0.20	0.42	0.30
Barium	µg/L	1,000	2,000	2.1	12.2	4.8
Boron	µg/L	1,500	5,000	<5	7.1	<5
Cadmium	µg/L	0.1	7	<0.005	<0.005	<0.005
Chromium	µg/L	1 (Cr VI)	50	<0.05	0.22	0.093
Copper	µg/L	2	1,000	0.5	**3.11**(c)	0.57
Iron	µg/L	300	300	<1	48.4	3.4
Lead	µg/L	1	5	<0.005	0.059	<0.005
Manganese (total)	µg/L	-	20	0.52	18.9	4.1
Manganese (dissolved)	µg/L	Variable(d)	-	0.08	11.4	2.8
Mercury	µg/L	0.026 (inorganic); 0.004 (methyl)	1	<0.0019	0.0039	<0.0019
Molybdenum	µg/L	73	-	0.34	3.1	1.4
Nickel	µg/L	25	-	0.5	0.99	0.76
Selenium	µg/L	1	50	<0.04	<0.04	<0.04
Silicon	µg/L	2,100	-	<50	560	130
Silver	µg/L	0.25	-	<0.005	0.0081	<0.005
Strontium	µg/L	30,000	7000	19.6	123	45.3
Thallium	µg/L	0.8	-	<0.002	0.0053	<0.002
Tin	µg/L	73	-	<0.01	0.184	<0.01
Uranium	µg/L	15	20	0.07	0.54	0.23
Zinc (total)	µg/L	-	5,000	<0.1	9.03	0.28
Zinc (dissolved)	µg/L	Variable(e)	-	<0.10	2.8	0.2

Note: **Bold** indicates a value exceeds the relevant Effects Benchmark.

a) The focus of the comparison was on dissolved oxygen concentrations less than 6.5 mg/L.

b) Variable with pH. Benchmark of 50 µg/L based on the median lab pH of 6.7.

c) This value was identified as anomalous during data screening.

d) Variable with pH and hardness. Benchmark value was calculated on a sample-by-sample basis.

e) Variable with pH, hardness, and DOC. Benchmark value was calculated on a sample-by-sample basis.

\- = not available; IC = ice-cover; OW = open-water.

3.2.6 Effluent Toxicity

The results of toxicity testing in 2020 indicated that effluent samples were not toxic to aquatic test organisms (Table 3-4 and Table 3-5). A total of 24 acute and chronic lethal toxicity tests and 22 sublethal toxicity tests were successfully conducted using eight treated effluent samples collected during the 2020 reporting period. Toxicity test results demonstrated no toxic effects to aquatic test organisms in all eight samples submitted for lethal testing. Sublethal testing also detected no adverse effects. Results of the sublethal *P. subcapitata* growth inhibition tests indicated that the effluent stimulated algal growth in all eight samples; however, this is not considered to be a toxic response. The raw toxicity data results (i.e., December 2019, January 2020, May 2020, and August 2020) are provided in Attachment E.

Table 3-4 Acute and Chronic Lethality Toxicity Testing Results, North Inlet Water Treatment Plant Effluent, 2020

Test Organism	Month	Station	
		SNP 1645-18	SNP 1645-18B
		100% effluent	100% effluent
Rainbow Trout[(a)]	December 2019	Pass	Pass
	January 2020	Pass	Pass
	May 2020	Pass	Pass
	August 2020	Pass	Pass
Daphnia magna[(a)]	December 2019	Pass	Pass
	January 2020	Pass	Pass
	May 2020	Pass	Pass
	August 2020	Pass	Pass
Ceriodaphnia dubia[(a)]	December 2019	Pass	Pass
	January 2020	Pass	Pass
	May 2020	Pass	Pass
	August 2020	Pass	Pass

a) Test is considered a “fail” if mortality is greater than or equal to 50%.

Table 3-5 Sublethal Toxicity Testing Results, North Inlet Water Treatment Plant Effluent, 2020

Test Organism	Month	Station	
		SNP 1645-18	SNP 1645-18B
		100% effluent	100% effluent
Rainbow Trout[a]	December 2019	Pass	Pass
	January 2020	—[b]	—[b]
	May 2020	Pass	Pass
	August 2020	Pass	Pass
Pseudokirchneriella subcapitata[c,d]	December 2019	Pass	Pass
	January 2020	Pass	Pass
	May 2020	Pass	Pass
	August 2020	Pass	Pass
Ceriodaphnia dubia[e]	December 2019	Pass	Pass
	January 2020	Pass	Pass
	May 2020	Pass	Pass
	August 2020	Pass	Pass

a) The 7-day Rainbow Trout embryo (early life stage) toxicity test is considered a "fail" if the relative percent difference in embryo viability between the two treatments (control and 100% concentration) is greater than or equal to 50%.

b) No results were reported for Rainbow Trout (early life stage) toxicity test in January 2020 for SNP 1645-18 or SNP 1645-18B due to laboratory issues with poor egg quality and logistical constraints with COVID-19 that prevented resampling within the first quarter of 2020.

c) Test is considered a "fail" if reduction in growth compared to control is greater than or equal to 50%.

d) Laboratory results indicate algal growth stimulation compared to control.

e) Test is considered a "fail" if the reduction in fecundity compared to control is greater than or equal to 50%.

3.3 Depth Profiles

This section describes the in situ (i.e., field-measured) water quality measurements for conductivity, DO, temperature, pH, and turbidity recorded at AEMP stations (Attachment D).

Specific conductivity generally increased with depth in the NF area during the ice-cover season to approximately 12 to 14 m depth and then declined slightly near the lake bottom (Figure 3-22). The greater specific gravity of the effluent, combined with the absence of wind and wave-driven mixing during ice-cover conditions, resulted in elevated conductivity in the bottom two-thirds of the water column in the NF area. The greater conductivity at this depth indicated the depth range where the effluent plume was located. Complete vertical mixing of the effluent was observed during ice-cover at all stations along the MF1 transect (Figure 3-23), and at most stations along the MF2 and the MF3 transects. Exceptions were noted at MF2-1, MF3-1, and MF3-2 (Figure 3-24 to Figure 3-25), which are located closest to the NF area and the diffusers along the MF2 and MF3 transects. Specific conductivity at MF2-1, MF3-1, and MF3-2 generally increased until approximately 16 m depth and then declined slightly with increasing water depth. During the open-water season, specific conductivity was typically uniform throughout the water column (Figure 3-22 to Figure 3-25).

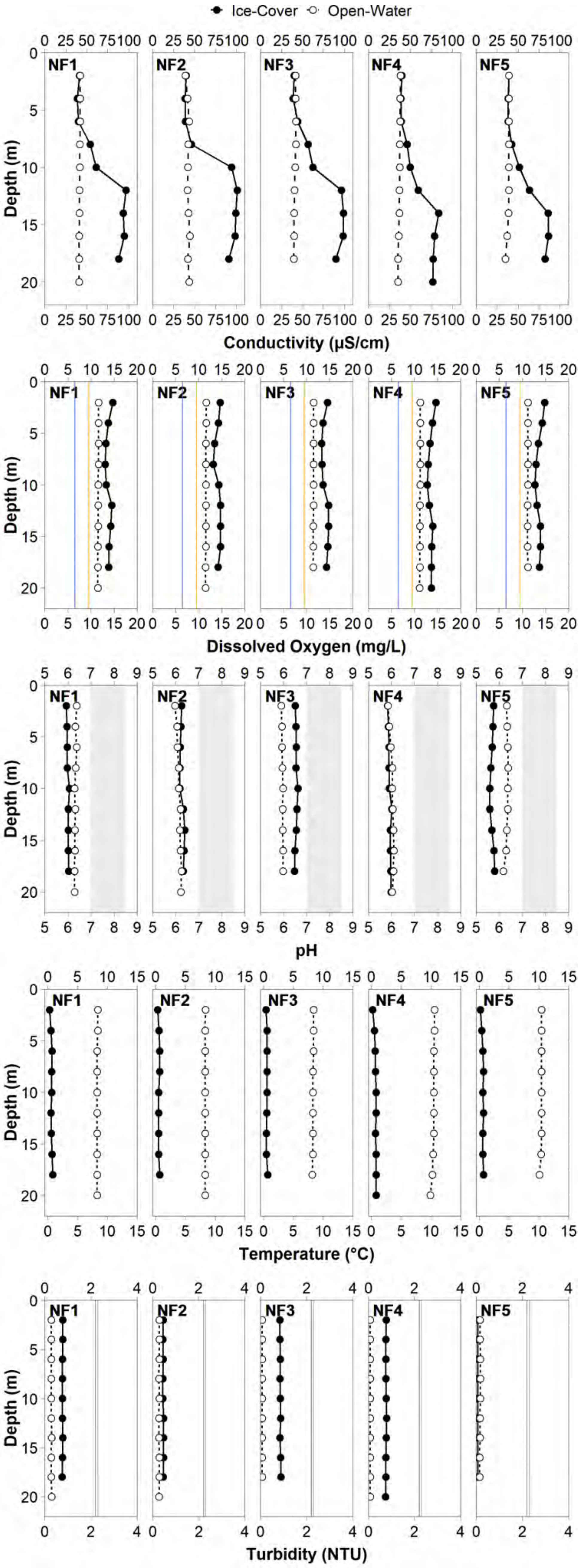
During the ice-cover season, DO concentrations were usually highest just below the ice and declined slightly with increasing depth. The greatest declines in DO near the lake bottom were measured at MF1-1, MF1-5, FF2-5, and MF3-5, where near-bottom DO concentrations were at or below the Effects Benchmark of 9.5 mg/L for the protection of aquatic life for early life stages. In addition, some concentrations measured at MF1-1, MF1-5, and FF2-5 during ice-cover were also below the Effects Benchmark of 6.5 mg/L for the protection of aquatic life for “other” life stages (i.e., non-early life stages). The lower DO values at these stations were unlikely to be Mine-related, as the reduction in DO near the lake bottom was not present in the NF area where the effect would be expected to be greatest, and because the measured values were within the range of concentrations observed during the *Winter Dissolved Oxygen Baseline Survey*, which occurred in 2000 prior to initiation of Mine discharge (DDMI 2000). During the open-water season, DO concentrations were typically uniform throughout the water column (Figure 3-22 to Figure 3-25).

During the ice-cover season, pH values were typically uniform throughout the water column or decreased slightly with depth (Figure 3-22). Slightly greater pH values closer to the water surface likely reflect the removal of dissolved carbon dioxide through photosynthesis. The pH values measured in Lac de Gras during the open-water season were typically uniform throughout the water column and less than or similar to values measured during the ice-cover season (Figure 3-22 to Figure 3-25). Field pH values were frequently below the drinking water Effects Benchmark value of 7.0 as well as the aquatic life Effects Benchmark value of 6.5 (median = 5.9; range = 5.2 to 6.7). These occurrences were likely natural and unrelated to Mine discharge, as the effluent is slightly alkaline (median pH of 7.3) and because there is no spatial pattern in pH in relation to the diffuser. Furthermore, values of pH below 6.5 naturally occur throughout Lac de Gras, during both the ice-cover and open-water seasons, at various depths, and over time (i.e., 2002 to 2019; Golder 2020b).

Water temperature in Lac de Gras increased gradually with depth at most stations during the ice-cover season (Figure 3-22 to Figure 3-25). During the open-water season, temperature profiles were vertically homogeneous or decreased with depth.

Turbidity was typically uniform throughout the water column during both the ice-cover and open-water seasons. Field turbidity values were within the respective Effects Benchmarks for ice-cover (2.2 NTU) and open-water (2.3 NTU) conditions, for all measurements.

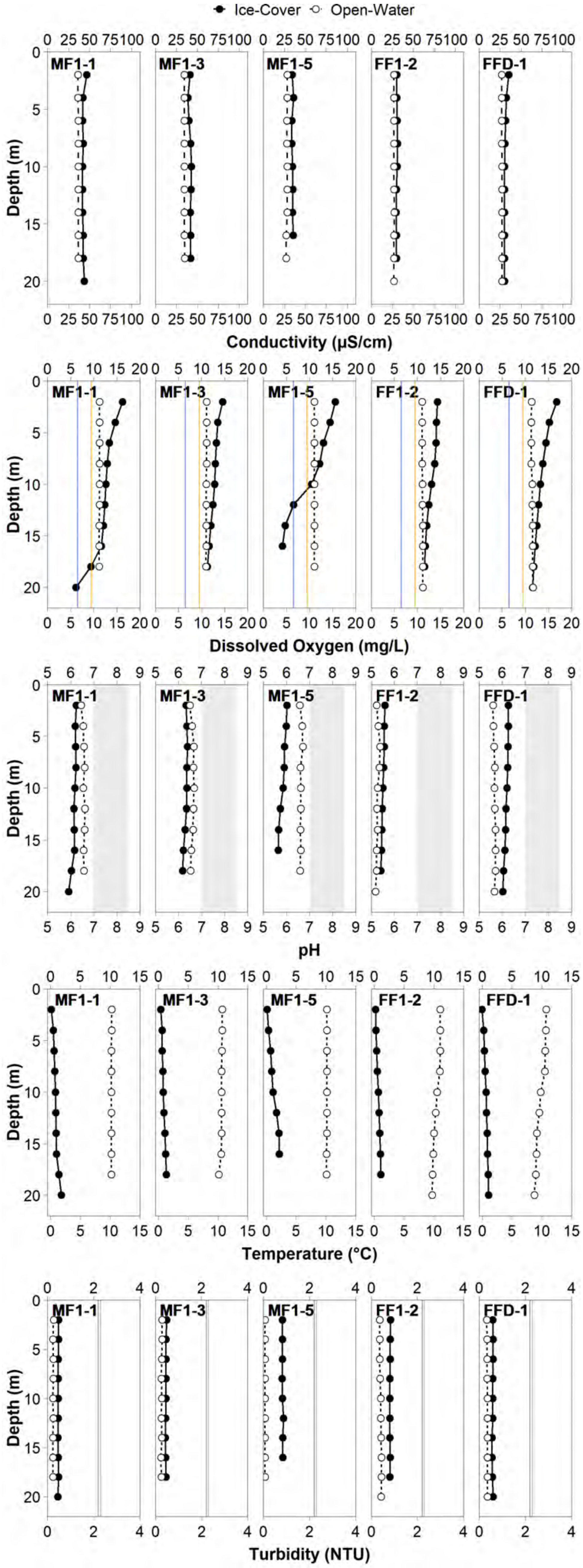
Figure 3-22 Specific Conductivity, Dissolved Oxygen, pH, Temperature, and Turbidity Profiles at NF Stations, 2020



Note: The yellow and blue lines shown on the dissolved oxygen, the grey lines shown on the turbidity profiles, and the grey shaded area shown on the pH profiles are the Effects Benchmarks for these variables. Details are provided in Section 2.4.4.3 and Table 2-5.

NF = near-field; µS/cm = microsiemens per centimetre; NTU = nephelometric turbidity unit.

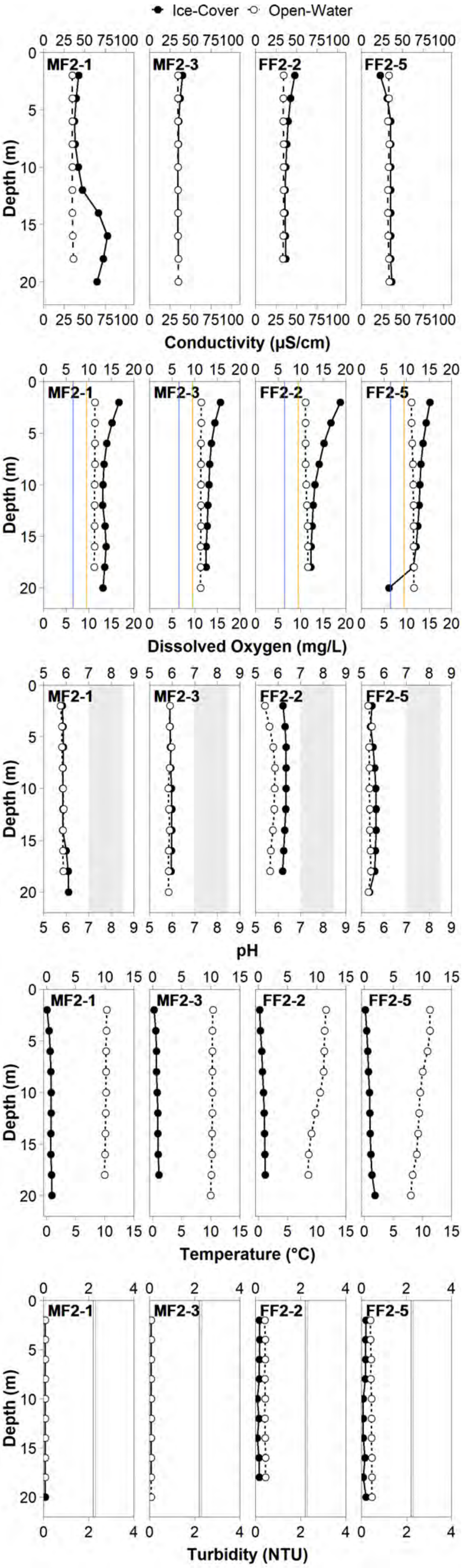
Figure 3-23 Specific Conductivity, Dissolved Oxygen, pH, Temperature, and Turbidity Profiles at MF1 Transect Stations, 2020



Note: The yellow and blue lines shown on the dissolved oxygen, the grey lines shown on the turbidity profiles, and the grey shaded area shown on the pH profiles are the Effects Benchmarks for these variables. Details are provided in Section 2.4.4.3 and Table 2-5.

MF = mid-field; FF = far-field; µS/cm = microsiemens per centimetre; NTU = nephelometric turbidity unit.

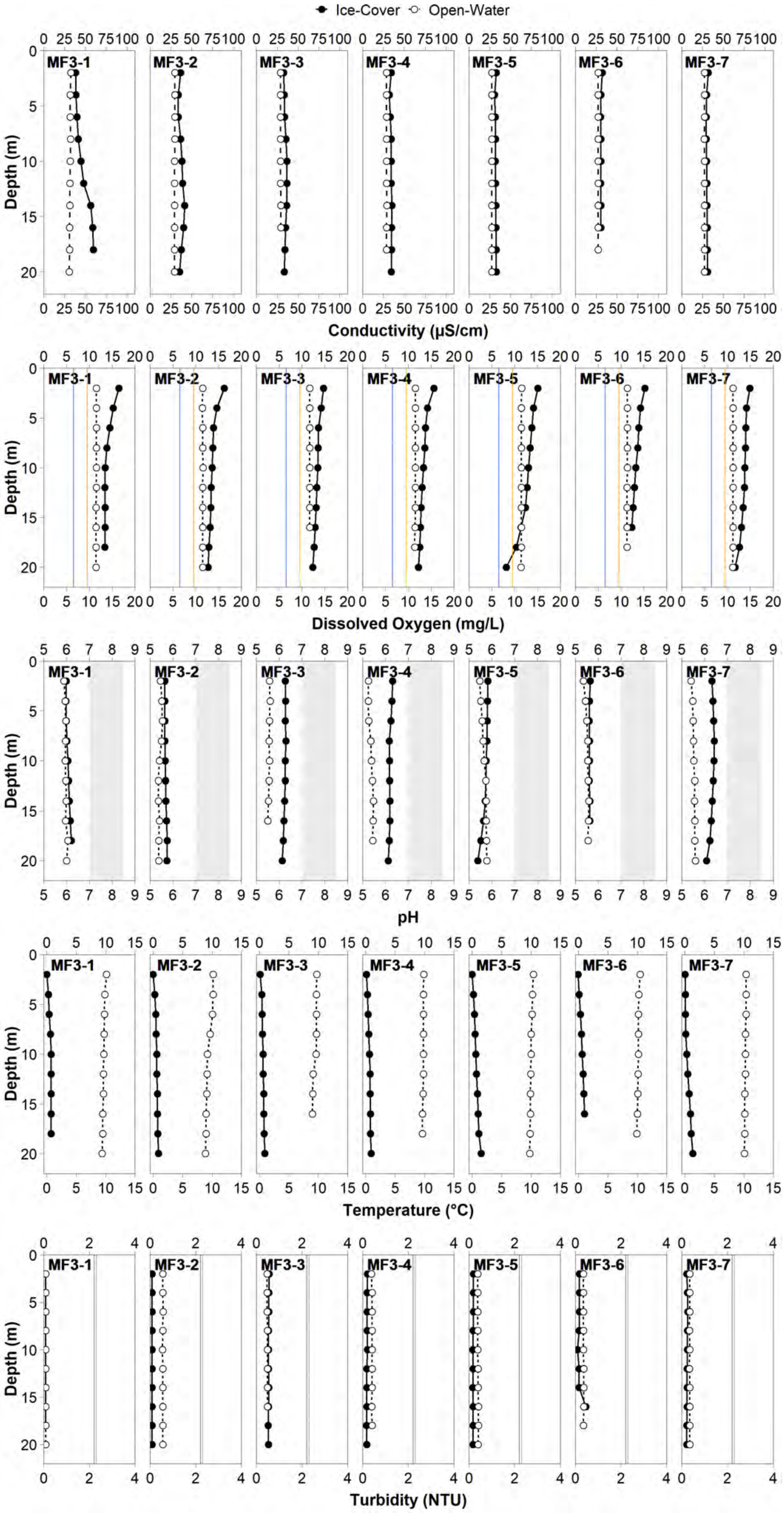
Figure 3-24 Specific Conductivity, Dissolved Oxygen, pH, Temperature, and Turbidity Profiles at MF2 Transect Stations, 2020



Note: The yellow and blue lines shown on the dissolved oxygen, the grey lines shown on the turbidity profiles and the grey shaded area shown on the pH profiles are the Effects Benchmarks for these variables. Details are provided in Section 2.4.4.3 and Table 2-5.

MF = mid-field; FF = far-field; µS/cm = microsiemens per centimetre; NTU = nephelometric turbidity unit.

Figure 3-25 Specific Conductivity, Dissolved Oxygen, pH, Temperature, and Turbidity Profiles at MF3 Transect Stations, 2020



Note: The yellow and blue lines shown on the dissolved oxygen, the grey lines shown on the turbidity profiles and the grey shaded area shown on the pH profiles are the Effects Benchmarks for these variables. Details are provided in Section 2.4.4.3 and Table 2-5.

MF = mid-field; FF = far-field; µS/cm = microsiemens per centimetre; NTU = nephelometric turbidity unit.

3.4 Comparison of AEMP Data to Effects Benchmarks

Concentrations of water quality variables at AEMP stations (Attachment D) were compared to the AEMP Effects Benchmarks listed in Table 2-5. This section provides a summary of benchmark exceedances noted for discrete water quality samples. A comparison of field-measured depth profile data to benchmarks is provided in Section 3.3.

- Two total manganese samples collected during the ice-cover season exceeded the drinking water Effects Benchmark of 20 µg/L, which is an aesthetic guideline applied to prevent undesirable tastes in beverages and staining of plumbing fixtures and laundry (Health Canada 2019). In addition, one dissolved manganese sample collected during the ice-cover season exceeded the aquatic life Effects Benchmark (varies with pH, dissolved organic carbon [DOC], and hardness). Samples with exceedances of the Effects Benchmark were:
    - MF1-5M (51.9 µg/L): the corresponding dissolved sample (33.6 µg/L) also exceeded the drinking water Effects Benchmark; however, the dissolved sample was below the aquatic life Effects Benchmark (230 µg/L). Samples collected at nearby stations, were generally well below the Effects Benchmarks, indicating that the sample may have been contaminated or that it may have been an error. The sample was not flagged as anomalous in the initial data screening (Section 2.4.2); however, the sample was elevated relative to other nearby stations indicating that the value was unusual compared to other samples collected in Lac de Gras.
    - MF1-5B (182 µg/L): the corresponding dissolved sample (289 µg/L) also exceeded the drinking water Effects Benchmark and the aquatic life Effects Benchmark (200 µg/L); however, samples collected at nearby stations, were generally well below the Effects Benchmark, indicating that the sample may have been contaminated. In addition, both the total and dissolved samples were flagged as anomalous in the initial data screening (Section 2.4.2), indicating that the value was extreme compared to other samples collected in Lac de Gras.
- Five dissolved zinc samples collected during the open-water season were above the aquatic life Effects Benchmark, which is variable with pH, hardness, and DOC (CCME 2018; Table 3-6). In all five cases, the total value was well below the dissolved concentration, indicating that the dissolved samples may have been contaminated (Table 3-6). Samples collected at nearby stations were well below the Effects Benchmark. The MF1-5M dissolved zinc result was flagged as anomalous in the initial data screening (Section 2.4.2), indicating that the value was extreme compared to other samples collected in Lac de Gras.
- Laboratory pH values were below the drinking water Effects Benchmark of 7 in 97% of samples. In addition, laboratory pH values (median = 6.7; range = 6.2 to 7.1) were below the aquatic life Effects Benchmark of 6.5 in seven samples collected during the ice-cover season and in ten samples collected during the open-water season. However, as is noted in Section 3.3 for field pH values that were below the Effects Benchmark, these occurrences were likely natural and unrelated to the Mine discharge.

Concentrations of all variables in all other samples collected during the 2020 AEMP were below the relevant Effects Benchmarks for the protection of aquatic life and drinking water (Attachment D).

Table 3-6 Dissolved Zinc Samples with Concentrations Above Effects Benchmarks

Station	Effects Benchmark (µg/L)	Dissolved Zinc Concentration (µg/L)	Total Zinc Concentration (µg/L)
NF3T	6.3	7.41	4.65
MF1-5M	5.1	16.1	0.99
MF3-2T	5.2	15.4	0.64
MF3-4T	5.0	6.79	0.24
MF3-7T	5.0	7.31	3.88

NF = near-field; MF = mid-field

3.5 Action Level Evaluation

Mine-related effects on water quality were categorized according to Action Levels (Table 2-6). Results of the Action Level screening are organized sequentially for each Action Level. Spatial variation in the concentrations of water quality variables that were identified as SOIs in 2020 are presented relative to Action Level values in Figure 3-26 to Figure 3-31.

3.5.1 Action Level 1

Action Level 1 was triggered for variables that had NF area median concentrations that were two times greater than the reference dataset median concentration defined in the *AEMP Reference Conditions Report Version 1.4* (Golder 2019a). In addition, the increase in concentration in the NF area had to be linked to the Mine (i.e., constituent detected in the Mine effluent at a higher concentration than in lake water, or in another Mine source such as dust) to trigger Action Level 1.

In total, 21 of the water quality variables assessed in 2020 triggered Action Level 1 (Table 3-7). Each of these variables was measured in the NIWTP effluent at concentrations greater than the concentration in Lac de Gras, with the exception of copper, which generally had similar to slightly lower concentrations in the effluent than in Lac de Gras. Variables that triggered Action Level 1, with the exception of boron and sulphur, were also detected in dust, which may be deposited episodically into Lac de Gras from mining activities (*Dust Deposition Report* [Appendix I]). This provides evidence of a link to the Mine, which is required for an Action Level 1 to be triggered. No management action is required under the Response Framework (Table 2-6) when a water quality variable triggers Action Level 1.

Variables that triggered Action Level 1 were retained as SOIs according to Criterion 3 (Section 2.4.1). For some variables that were analyzed in more than one form or as different fractions (e.g., total and dissolved), the most representative of these was included as an SOI to avoid duplication. For example, while both calculated and measured TDS triggered Action Level 1, to avoid redundancy, the analysis was focused on calculated TDS. Total and dissolved calcium, magnesium, potassium, and sodium in the NF area triggered Action Level 1. The total fractions were considered SOIs due to potential contamination of some major ions, as discussed in Section 2.3.2 and Attachment B.

Of the 21 variables that triggered Action Level 1, 11 (i.e., TDS, calcium, chloride, sodium, sulphate, nitrate, antimony, molybdenum, silicon, strontium, and uranium) had NF area median concentrations that exceeded two times the reference dataset median concentration during both the ice-cover and open-water seasons. Three variables (i.e., TSS, ammonia, and potassium) triggered Action Level 1 during the open-water season only. The remaining seven variables (i.e., turbidity, magnesium, aluminum, barium, chromium, copper, and sulphur) triggered Action Level 1 during the ice-cover season only.

3.5.2 Action Level 2

All SOIs that triggered Action Level 1 were evaluated against Action Level 2. Action Level 2 was triggered if the 5th percentile concentration in the NF area was greater than two times the median concentration in the reference condition dataset, and greater than the normal range for Lac de Gras. Of the 21 SOIs that triggered Action Level 1, eight (i.e., TDS, chloride, sodium, sulphate, nitrate, molybdenum, strontium, and uranium) triggered Action Level 2 in one or both sampling seasons (Table 3-8). In most cases, Action Level 2 was triggered during both the ice-cover and open-water seasons. Exceptions were sulphate and uranium, which triggered Action Level 2 only during the open-water season.

Under the Response Framework, when a water quality variable triggers Action Level 2, the required management action is to establish an AEMP Effects Benchmark for that variable, if one does not already exist. Each of the eight variables that triggered Action Level 2 in 2020 have existing Effects Benchmarks (Table 2-5).

3.5.3 Action Level 3

Variables that triggered Action Level 2 were evaluated for an effect at Action Level 3. Action Level 3 was triggered if the 75th percentile concentration at the mixing zone boundary was greater than the normal range plus 25% of the distance between the top of the normal range and the AEMP Effects Benchmark. None of the water quality variables triggered Action Level 3 (Table 3-9). The 75th percentile concentrations of TDS, the major ions and nitrate at the mixing zone were two to five times less than the Action Level 3 criterion in both seasons. The 75th percentile concentrations of the total metals were eight to 41 times less than the Action Level 3 criterion in both seasons.

Table 3-7 Comparison of 2020 Water Quality Data to Action Level 1

Variable	Unit	2020 Detection Limit	Action Level 1 Criteria and 2020 AEMP Results					
			Action Level 1 Criterion		2020 AEMP		Action Level 1 Triggered? (Yes/No)	
			2× Median of Reference Datasets(a)		Median of NF values(b)			
			Ice-cover	Open-water	Ice-cover	Open-water	Ice-cover	Open-water
Conventional Parameters								
Total alkalinity	mg/L	0.5	8.8	8.0	5.8	5.6	No	No
Total dissolved solids, calculated	mg/L	-	10.7	10.0	**24**	**21**	**Yes**	**Yes**
Total dissolved solids, measured	mg/L	1	30	20	**31**	**26**	(c)	(c)
Total suspended solids	mg/L	1	1.0	1.0	<1	**1.3**	No	**Yes**
Total organic carbon	mg/L	0.2	5.2	4.4	2.1	2.5	No	No
Turbidity – lab	NTU	0.1	0.10	0.42	**0.13**	0.23	**Yes**	No
Major Ions								
Calcium (dissolved)	mg/L	0.01	2.2	2.0	**3.0**	**2.1**	(d)	(d)
Chloride	mg/L	0.5	1.6	2.0	**6.6**	**4.4**	**Yes**	**Yes**
Fluoride	mg/L	0.01	0.048	0.044	0.036	0.029	No	No
Magnesium (dissolved)	mg/L	0.005	1.38	1.4	**1.4**	1.2	(d)	No
Potassium (dissolved)	mg/L	0.01	1.26	1.2	1.1	**1.2**	No	(d)
Sodium (dissolved)	mg/L	0.01	1.0	1.0	**3.7**	**3.2**	(d)	(d)
Sulphate	mg/L	0.5	4.4	3.8	**4.8**	**5.1**	**Yes**	**Yes**
Nutrients								
Ammonia	µg/L	5	36	5	28	**6.9**	No	**Yes**
Nitrate	µg-N/L	2	6.8	2.0	**120**	**44**	**Yes**	**Yes**
Nitrite	µg-N/L	1	2	2	<1	<1	No	No
Total Metals								
Aluminum	µg/L	0.2	5.8	8.8	**5.9**	6.2	**Yes**	No
Antimony	µg/L	0.02	0.02	0.02	**0.023**	**0.023**	**Yes**	**Yes**
Arsenic	µg/L	0.02	0.38	0.34	0.31	0.26	No	No
Barium	µg/L	0.02	3.86	3.62	**4.64**	3.13	**Yes**	No
Beryllium	µg/L	0.01	0.01	0.01	<0.01	<0.01	No	No
Bismuth	µg/L	0.005	0.005	0.005	<0.005	<0.005	No	No
Boron	µg/L	5	5	5	<5	<5	No	No
Cadmium	µg/L	0.005	0.005	0.005	<0.005	<0.005	No	No
Calcium	mg/L	0.01	2.04	1.92	**2.73**	**2.04**	**Yes**	**Yes**
Chromium	µg/L	0.05	0.06	0.06	**0.07**	<0.05	**Yes**	No
Cobalt	µg/L	0.005	0.022	0.04	0.015	0.017	No	No
Copper	µg/L	0.05	0.6	0.6	**0.63**	0.56	**Yes**	No
Iron	µg/L	1	5	10	<1	4.5	No	No
Lead	µg/L	0.005	0.005	0.005	<0.005	<0.005	No	No
Lithium	µg/L	0.5	2.8	2.4	2.22	1.59	No	No
Magnesium	mg/L	0.005	1.32	1.26	**1.43**	1.16	**Yes**	No
Manganese	µg/L	0.05	2.42	4.88	2.15	1.8	No	No
Mercury	µg/L	0.0019	0.01	0.01	<0.0019	<0.0019	No	No
Molybdenum	µg/L	0.05	0.14	0.18	**0.82**	**0.92**	**Yes**	**Yes**

Table 3-7 Comparison of 2020 Water Quality Data to Action Level 1 (continued)

Variable	Unit	2020 Detection Limit	Action Level 1 Criteria and 2020 AEMP Results					
			Action Level 1 Criterion		2020 AEMP		Action Level 1 Triggered? (Yes/No)	
			2× Median of Reference Datasets[(a)]		Median of NF values[(b)]			
			Ice-cover	Open-water	Ice-cover	Open-water	Ice-cover	Open-water
Nickel	µg/L	0.02	1.94	1.9	0.88	0.70	No	No
Potassium	mg/L	0.01	1.16	1.08	1.12	**1.13**	No	**Yes**
Selenium	µg/L	0.04	0.04	0.04	<0.04	<0.04	No	No
Silicon	µg/L	50	50	50	**174**	**71**	**Yes**	**Yes**
Silver	µg/L	0.005	0.005	0.005	<0.005	<0.005	No	No
Sodium	mg/L	0.01	1.28	1.26	**3.62**	**2.93**	**Yes**	**Yes**
Strontium	µg/L	0.05	15.2	14.6	**37.1**	**27.7**	**Yes**	**Yes**
Sulphur	mg/L	0.5	1.96	1.82	**2.33**	1.7	**Yes**	No
Thallium	µg/L	0.002	0.002	0.002	<0.002	<0.002	No	No
Tin	µg/L	0.01	0.01	0.01	<0.01	<0.01	No	No
Titanium	µg/L	0.5	0.5	0.5	<0.5	<0.5	No	No
Uranium	µg/L	0.002	0.056	0.056	**0.17**	**0.14**	**Yes**	**Yes**
Vanadium	µg/L	0.05	0.1	0.1	<0.05	<0.05	No	No
Zinc	µg/L	0.1	1.8	1.5	0.3	0.9	No	No
Zirconium	µg/L	0.05	0.05	0.05	<0.05	<0.05	No	No

a) The 2× median value was based on the reference condition dataset median concentrations presented in the *AEMP Reference Conditions Report Version 1.4* (Golder 2019a). In cases where the median concentration was less than the DL, the reference condition median value was considered to be equal to 0.5 of the DL.

b) The median of NF area values was calculated from data pooled across all sample depths, dates and stations (n = 15 samples).

c) Action Level 1 comparison was applied to an alternate form or fraction of this substance (e.g., dissolved rather than total; calculated rather than measured) to avoid duplication.

d) Review of the analytical data in 2020 indicated that some major ions and dissolved metals AEMP samples from the open-water season were potentially contaminated (Section 2.3.2; Attachment B); therefore, analyses involving the AEMP data were presented for the total fractions.

Note: **Bold** indicates a value exceeds the Action Level 1 criterion.

- = not applicable; NTU = nephelometric turbidity unit; µg-N/L = micrograms nitrogen per litre; 2× = two times; NF = near-field.

Table 3-8 Comparison of 2020 Water Quality Data to Action Level 2

Variable	Unit	2020 Detection Limit	Action Level 2 Criteria and 2020 AEMP Results							
			Action Level 2 Criteria				2020 AEMP Result		Action Level 2 Triggered? (Yes/No)	
			2× Median of Reference Areas(a)		Top of Normal Range		5th Percentile of NF values(b)			
			Ice-cover	Open-water	Ice-cover	Open-water	Ice-cover	Open-water	Ice-cover	Open-water
Conventional Parameters										
Total dissolved solids, calculated	mg/L	-	10.7	10.0	6.5	5.8	**17.1**	**17.5**	**Yes**	**Yes**
Total suspended solids	mg/L	1	1.0	1.0	1.0	1.0	<1	<1	No	No
Turbidity – lab	NTU	0.1	0.1	0.42	0.18	0.29	<0.1	<0.1	No	No
Major Ions										
Calcium (dissolved)	mg/L	0.01	2.2	2.0	1.3	1.1	1.8	1.9	No	No
Chloride	mg/L	0.5	1.6	2.0	1.0	1.0	**3.8**	**3.5**	**Yes**	**Yes**
Magnesium (dissolved)	mg/L	0.005	1.4	1.4	0.8	0.8	1.1	1.1	No	No
Potassium (dissolved)	mg/L	0.01	1.26	1.2	0.8	0.7	0.84	0.99	No	No
Sodium (dissolved)	mg/L	0.01	1.0	1.0	1.0	1.0	**2.2**	**2.5**	(c)	(c)
Sulphate	mg/L	0.5	4.4	3.8	2.5	2.1	4.1	**4.3**	No	**Yes**
Nutrients										
Ammonia	µg-N/L	5	36	5	23	5	19	<5	No	No
Nitrate	µg-N/L	2	6.8	2	15.2	2	**31.5**	**18.7**	**Yes**	**Yes**
Total Metals										
Aluminum	µg/L	0.2	5.8	8.8	3.9	6.2	2.0	4.7	No	No
Antimony	µg/L	0.02	0.02	0.02	0.02	0.02	<0.02	<0.02	No	No
Barium	µg/L	0.02	3.86	3.62	2.18	1.94	2.36	2.62	No	No
Calcium	mg/L	0.01	2.04	1.92	1.15	1.0	1.75	1.87	No	No
Chromium	µg/L	0.05	0.06	0.06	0.06	0.06	<0.05	<0.05	No	No
Copper	µg/L	0.05	0.6	0.6	0.8	0.6	0.5	0.5	No	No
Magnesium	mg/L	0.005	1.32	1.26	0.79	0.66	1.05	1.06	No	No
Molybdenum	µg/L	0.05	0.14	0.18	0.09	0.13	0.27	0.62	**Yes**	**Yes**
Potassium	mg/L	0.01	1.16	1.08	0.67	0.57	0.85	1.0	No	No
Silicon	µg/L	50	50	50	50	50	<50	<50	No	No
Sodium	mg/L	0.01	1.28	1.26	0.75	0.68	**2.14**	**2.50**	**Yes**	**Yes**
Strontium	µg/L	0.05	15.2	14.6	8.78	8.01	**18.9**	**24.8**	**Yes**	**Yes**

Table 3-8 Comparison of 2020 Water Quality Data to Action Level 2 (continued)

Variable	Unit	2020 Detection Limit	Action Level 2 Criteria and 2020 AEMP Results							
			Action Level 2 Criteria				2020 AEMP Result		Action Level 2 Triggered? (Yes/No)	
			2× Median of Reference Areas[(a)]		Top of Normal Range		5th Percentile of NF values[(b)]			
			Ice-cover	Open-water	Ice-cover	Open-water	Ice-cover	Open-water	Ice-cover	Open-water
Sulphur	mg/L	0.5	1.96	1.82	1.07	1.32	1.73	1.24	No	No
Uranium	µg/L	0.002	0.056	0.056	0.03	0.029	0.051	**0.094**	No	**Yes**

a) The 2× median value was based on the reference condition dataset median concentrations presented in the *AEMP Reference Conditions Report Version 1.4* (Golder 2019a). In cases where the median concentration was less than the DL, the reference condition median value was considered to be equal to 0.5 of the DL. Normal ranges are those presented in the *AEMP Reference Conditions Report, Version 1.4* (Golder 2019a).

b) The 5th percentile concentration of NF area values was calculated from data pooled across all sample depths, dates and stations (n = 15 samples).

c) Review of the analytical data in 2020 indicated that some major ions and dissolved metals AEMP samples from the open-water season were potentially contaminated (Section 2.3.2; Attachment B); therefore, analyses involving the AEMP data were presented for the total fractions.

Note: **Bold** indicates a value exceeds the Action Level 2 Criteria.

- = not applicable; NTU = nephelometric turbidity unit; µg-N/L = micrograms nitrogen per litre; 2× = two times; NF = near-field.

Table 3-9 Comparison of 2020 Water Quality Data to Action Level 3

Variable	Unit	2020 Detection Limit	AEMP Effects Benchmark[(a)]	Action Level 3 Criteria and 2020 AEMP Results					
				Action Level 3 Criterion		2020 AEMP Results		Action Level 3 Triggered (Yes/No)	
				Normal Range[(b)] + 25% of Effects Benchmark		75th Percentile of Mixing Zone Values[(c)]			
				Ice-cover	Open-water	Ice-cover	Open-water	Ice-cover	Open-water
Conventional Parameters									
Total dissolved solids, calculated	mg/L	-	500	129.9	129.4	44.5	26.3	No	No
Major Ions									
Chloride	mg/L	0.5	120	30.8	30.8	15.0	6.5	No	No
Sodium (dissolved)[(d)]	mg/L	0.01	52	13.8	13.8	7.27	3.9	No	No
Sulphate	mg/L	0.5	100	26.9	26.6	7.7	6.8	No	No
Nutrients									
Nitrate	µg-N/L	2	3,000	761	752	190	135	No	No
Total Metals									
Total Molybdenum	µg/L	0.05	73	18.3	18.3	2.1	1.4	No	No
Total Strontium	µg/L	0.05	7,000	1,757	1,756	87	43	No	No
Total Uranium	µg/L	0.002	15	3.8	3.8	0.40	0.22	No	No

a) The AEMP Effects Benchmarks are described in the *AEMP Design Plan Version 4.1* (Golder 2017a) and in Section 2.4.4.3.

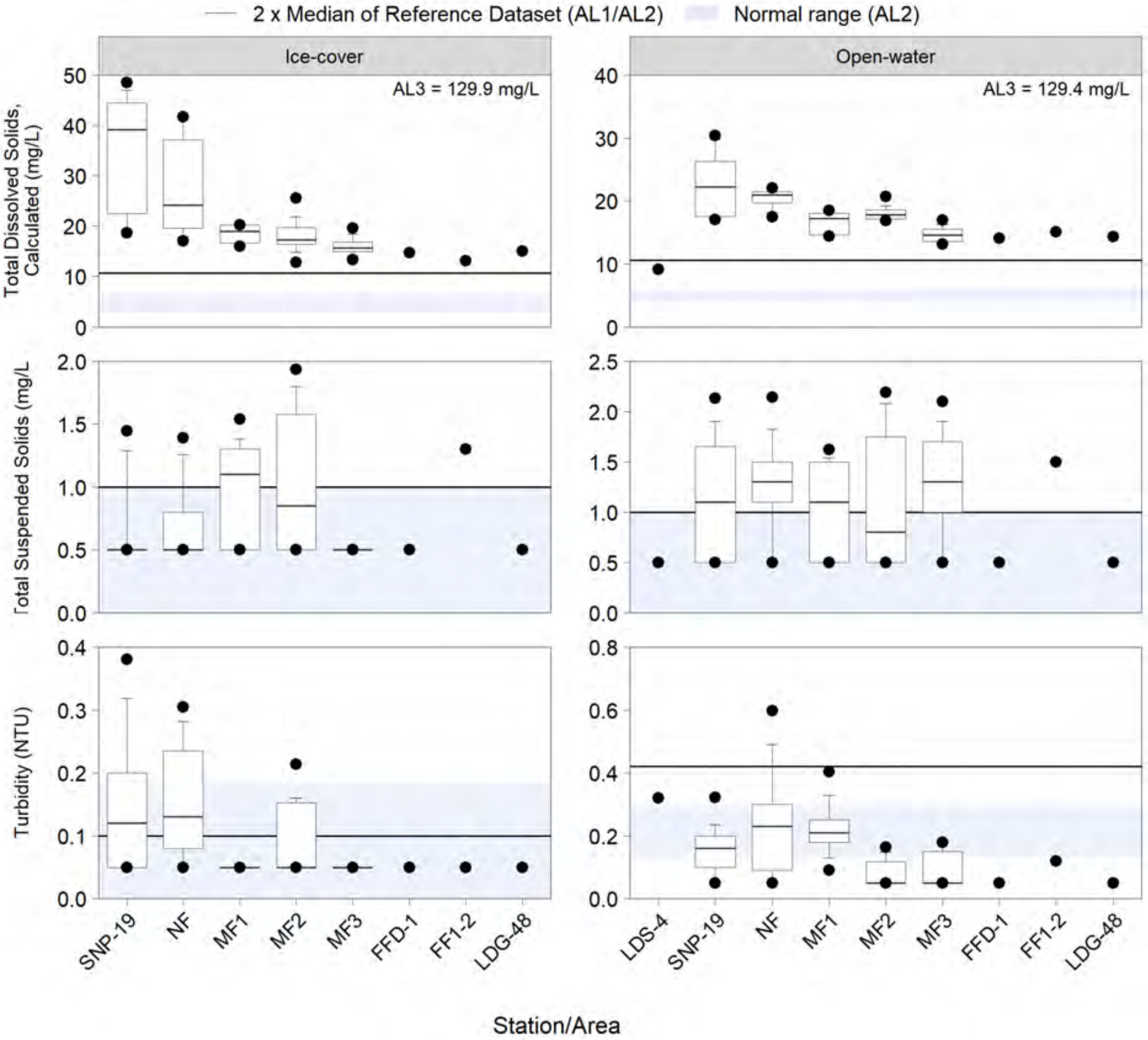
b) Normal ranges are those presented in the *AEMP Reference Conditions Report Version 1.4* (Golder 2019a).

c) The 75th percentile of mixing zone values were calculated from data pooled across all sample depths, dates and stations.

d) Dissolved sodium was evaluated in Action Level 3 as contamination of dissolved metals was not observed for the mixing zone samples. In addition, the Effects Benchmark for sodium was derived for the dissolved form.

- = not applicable; µg-N/L = micrograms nitrogen per litre.

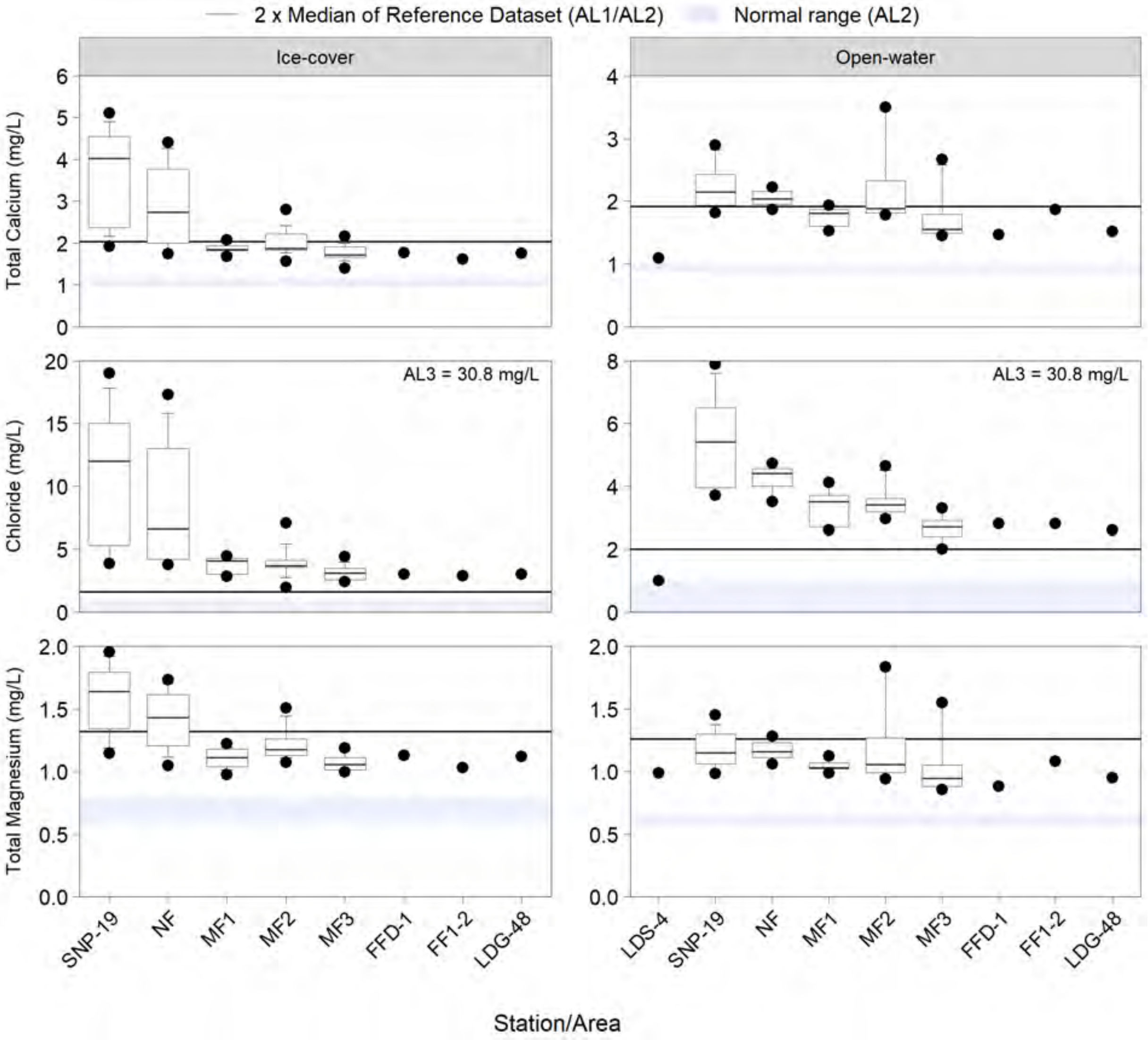
Figure 3-26 Total Dissolved Solids, Calculated, Total Suspended Solids, and Turbidity at AEMP Stations Relative to the Normal Range and Action Level Criteria, 2020



Notes: Boxplots represent the 10th, 25th, 50th (median), 75th, and 90th percentile concentrations in each sampling area. Black symbols in the boxplots represent the 5th (on the bottom) and 95th (on the top) percentiles, except in cases with three or less data points, where the reported values are shown.

AL = Action Level; 2× = two times; SNP-19 = Mixing Zone; NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage.

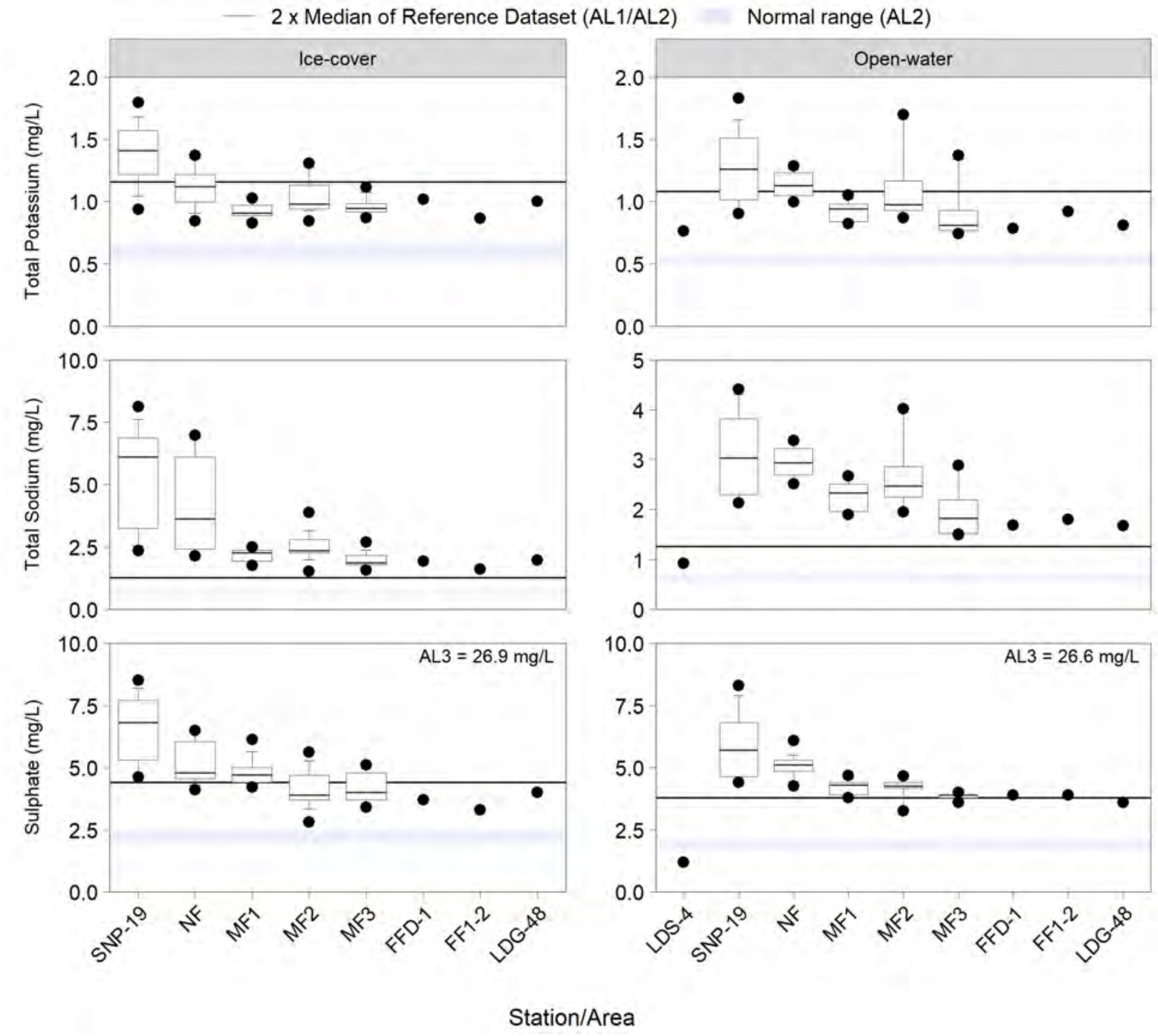
Figure 3-27 Concentration of Calcium (Total), Chloride, and Magnesium (Total) at AEMP Stations Relative to the Normal Range and Action Level Criteria, 2020



Notes: Boxplots represent the 10th, 25th, 50th (median), 75th, and 90th percentile concentrations in each sampling area. Black symbols in the boxplots represent the 5th (on the bottom) and 95th (on the top) percentiles, except in cases with three or less data points, where the reported values are shown.

AL = Action Level; 2× = two times; SNP-19 = Mixing Zone; NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage.

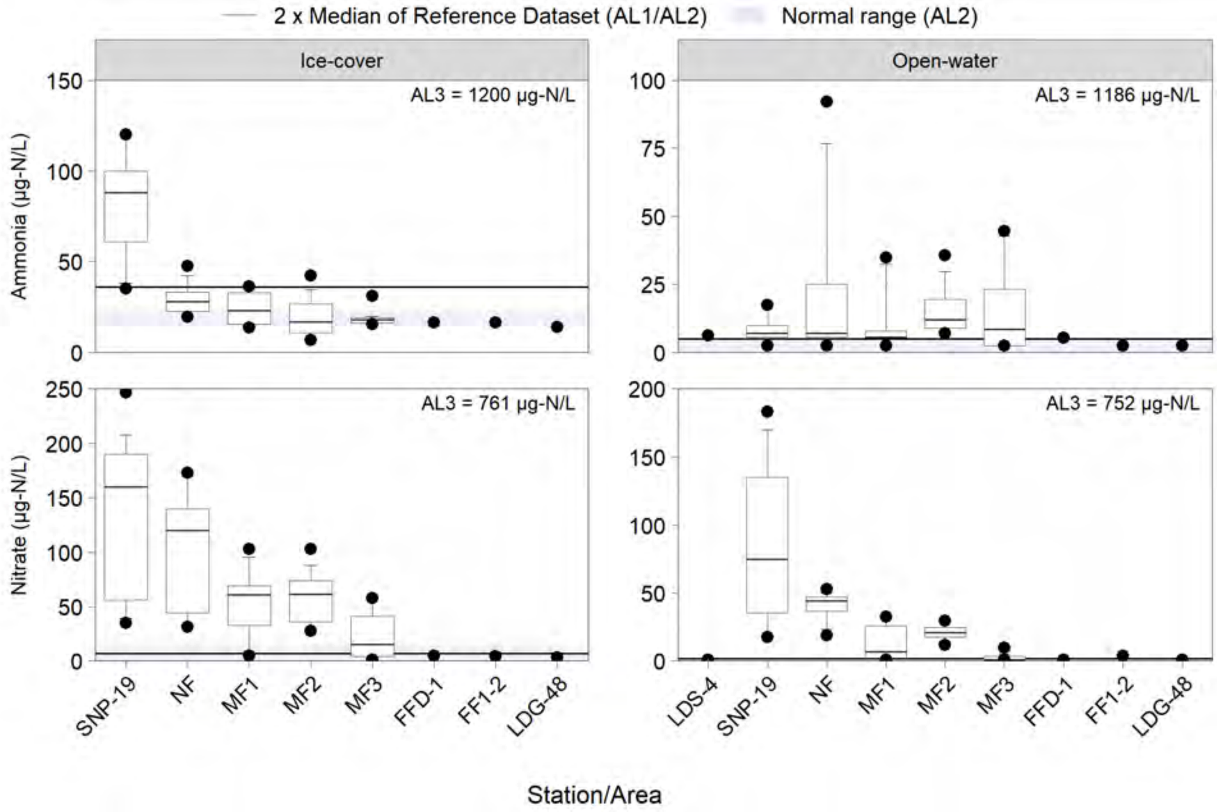
Figure 3-28 **Concentration of Potassium (Total), Sodium (Total), and Sulphate at AEMP Stations Relative to the Normal Range and Action Level Criteria, 2020**



Notes: Boxplots represent the 10th, 25th, 50th (median), 75th, and 90th percentile concentrations in each sampling area. Black symbols in the boxplots represent the 5th (on the bottom) and 95th (on the top) percentiles, except in cases with three or less data points, where the reported values are shown.

AL = Action Level; 2× = two times; SNP-19 = Mixing Zone; NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage.

Figure 3-29 Concentration of Ammonia and Nitrate at AEMP Stations Relative to the Normal Range and Action Level Criteria, 2020

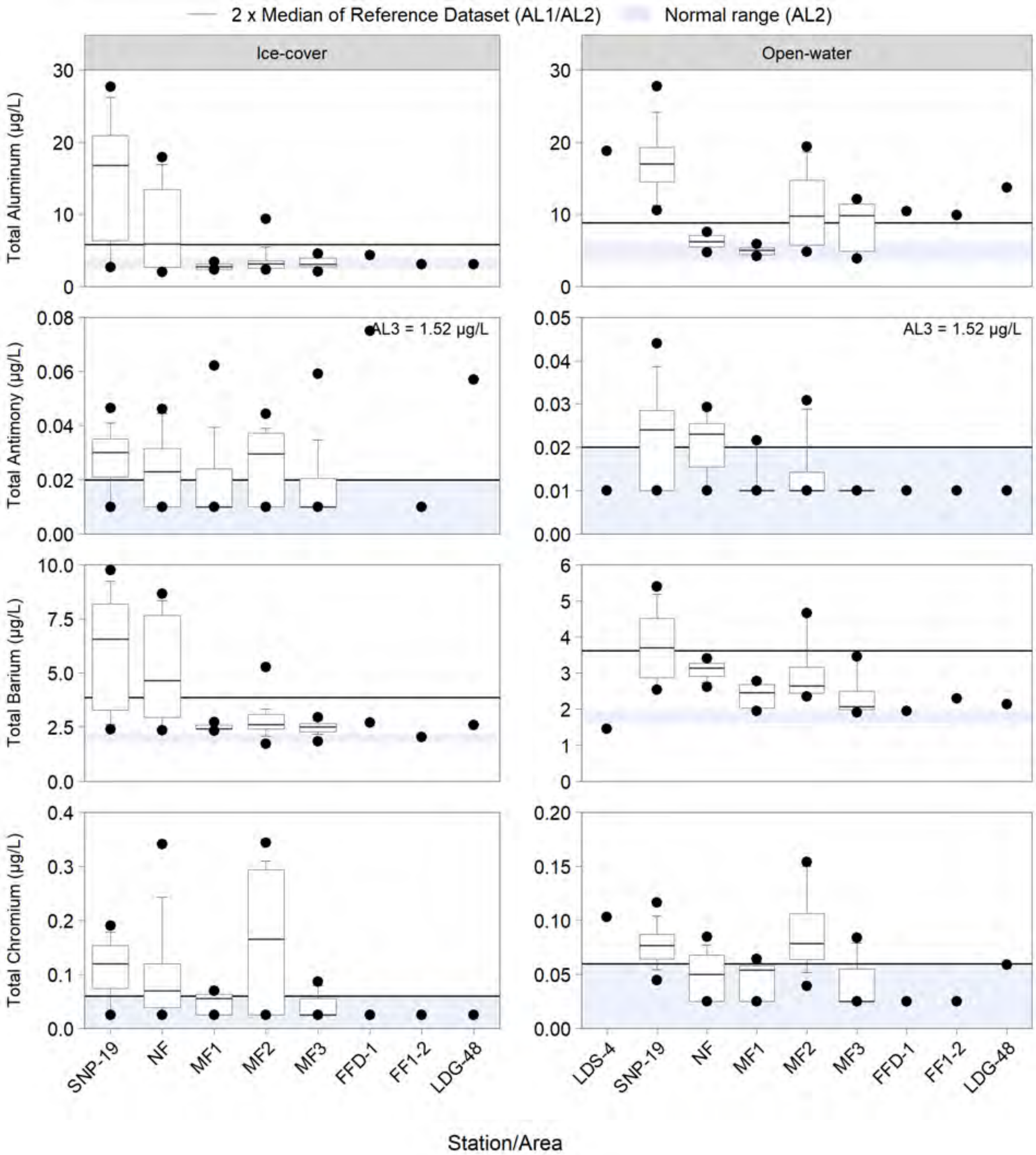


Notes: Boxplots represent the 10th, 25th, 50th (median), 75th, and 90th percentile concentrations in each sampling area. Black symbols in the boxplots represent the 5th (on the bottom) and 95th (on the top) percentiles, except in cases with three or less data points, where the reported values are shown.

Based on the results of the ammonia investigation, the ALS ammonia dataset was used in both seasons (Section 2.3.1, Attachment B).

AL = Action Level; 2× = two times; SNP-19 = Mixing Zone; NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage.

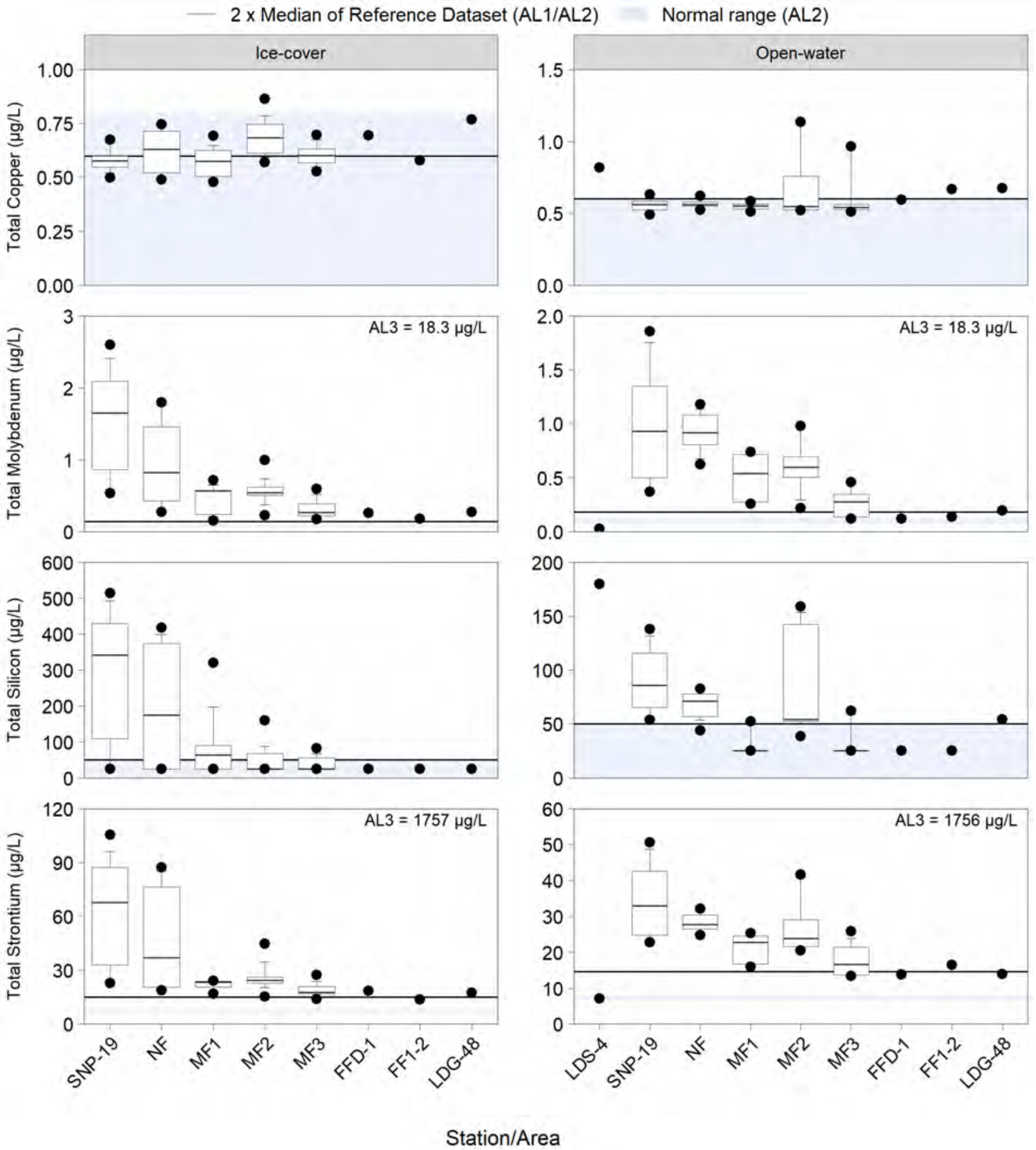
Figure 3-30 **Concentration of Total Aluminum, Total Antimony, Total Barium, and Total Chromium at AEMP Stations Relative to the Normal Range and Action Level Criteria, 2020**



Notes: Boxplots represent the 10th, 25th, 50th (median), 75th, and 90th percentile concentrations in each sampling area. Black symbols in the boxplots represent the 5th (on the bottom) and 95th (on the top) percentiles, except in cases with three or less data points, where the reported values are shown.

AL = Action Level; 2× = two times; SNP-19 = Mixing Zone; NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage.

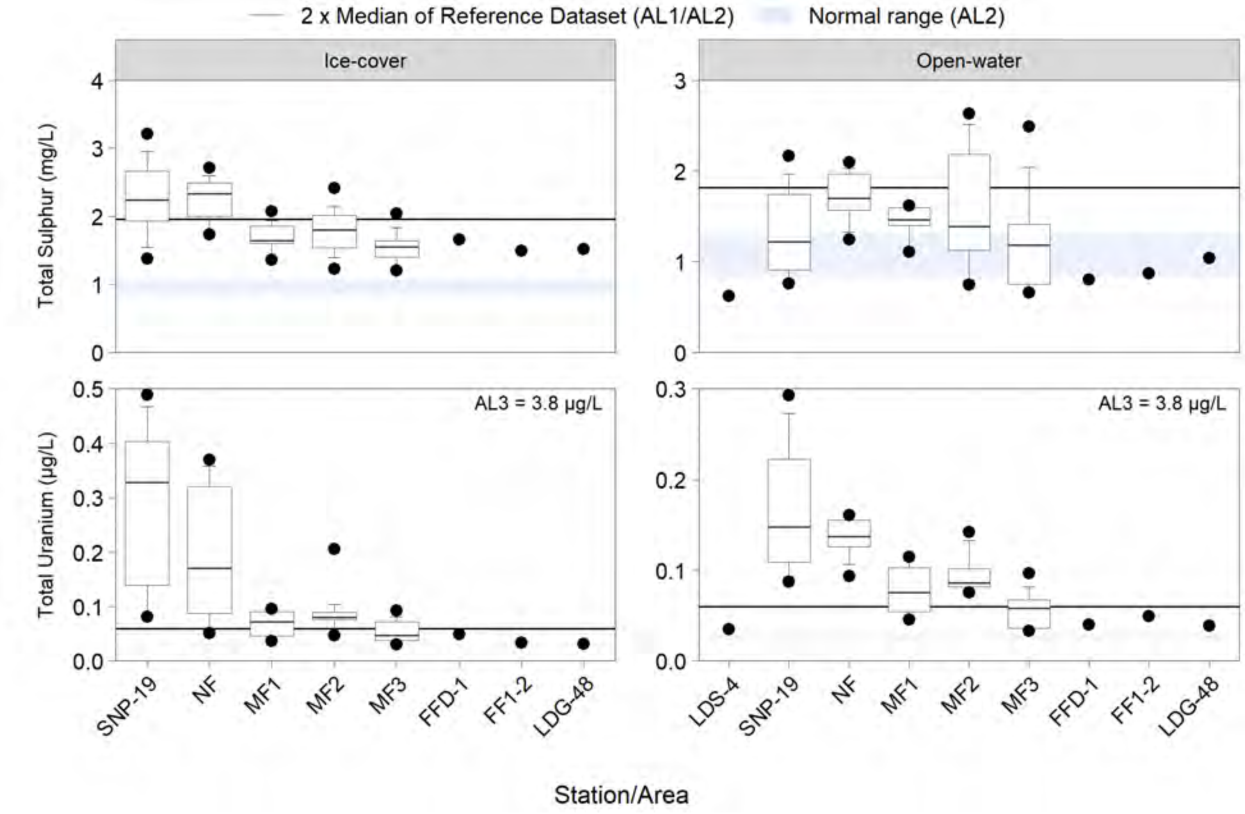
Figure 3-31 Concentration of Total Copper, Total Molybdenum, Total Silicon, and Total Strontium at AEMP Stations Relative to the Normal Range and Action Level Criteria, 2020



Notes: Boxplots represent the 10th, 25th, 50th (median), 75th, and 90th percentile concentrations in each sampling area. Black symbols in the boxplots represent the 5th (on the bottom) and 95th (on the top) percentiles, except in cases with three or less data points, where the reported values are shown.

AL = Action Level; 2× = two times; SNP-19 = Mixing Zone; NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage.

Figure 3-32 Concentration of Total Sulphur and Total Uranium at AEMP Stations Relative to the Normal Range and Action Level Criteria, 2020



Notes: Boxplots represent the 10th, 25th, 50th (median), 75th, and 90th percentile concentrations in each sampling area. Black symbols in the boxplots represent the 5th (on the bottom) and 95th (on the top) percentiles, except in cases with three or less data points, where the reported values are shown.

AL = Action Level; 2× = two times; SNP-19 = Mixing Zone; NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage.

3.6 Gradient Analysis

Substances of interest were evaluated statistically to determine whether there were trends in the concentrations of SOIs along the three MF transects. A pattern of significantly decreasing concentration with increasing distance from the diffusers was considered confirmation that the increases observed in the NF area were related to the Mine effluent discharge. Trends were identified using linear regression analysis (Section 2.4.5.2) and a graphical (i.e., visual) evaluation of the data plotted by distance from the diffusers (Figure 3-33 to Figure 3-53).

The concentrations of SOIs at the Lac de Gras outflow to the Coppermine River (LDG-48) and the Lac du Sauvage outflow to Lac de Gras (LDS-4), were compared qualitatively to those at AEMP stations within the main body of Lac de Gras to evaluate differences in SOI concentrations flowing into and out of the lake.

In general, clear spatial trends of decreasing concentrations with distance from the Mine effluent diffusers were evident for most variables that triggered Action Levels. Spatial trends were generally more pronounced during the ice-cover season than during open-water conditions. Further details are provided in the subsections that follow for individual SOIs that met Criteria 1 to 3 (Section 2.4.1).

3.6.1 Conventional Variables, Total Dissolved Solids, and Associated Ions

Linear regressions were not performed for turbidity (both seasons; Figure 3-33) and TSS (both seasons; Figure 3-34), due to the considerations discussed in Section 2.4.5.2. Visual evaluation of the plots for both variables suggests slight decreasing trends with distance from the diffusers.

During the ice-cover season, gradient analysis indicated that TDS and most major ions (i.e., calcium, chloride, magnesium, sodium, and sulphate) had significant decreasing trends with distance from the diffuser along all three MF transects. Potassium had significant decreasing trends along only two (i.e., MF1 and MF3) of the three MF transects (Table 3-10; Figure 3-33 to Figure 3-41).

During the open-water season, TDS, calcium, and chloride had significant decreasing trends along only two (i.e., MF1 and MF3) of the three MF transects. Magnesium, potassium, sodium, and sulphate had significant decreasing trends with distance from the diffuser along all three MF transects.

The spatial analysis of the MF3 transect involved the use of a piecewise model (Model 3) during both the ice-cover and open-water seasons for calcium, chloride, magnesium, and sodium, during the ice-cover season for TDS, and during the open-water season for potassium. Breakpoints in the piecewise model generally occurred between three and six kilometres from the effluent discharge. The piecewise analysis for these parameters indicated a more pronounced decrease in concentration at stations closer to the effluent discharge (i.e., stations located within 3 to 6 km of the effluent discharge) compared to stations farther away, and compared to SOIs that were analyzed using a standard linear approach. The trend direction for magnesium in the open-water season changed from a decreasing trend for the first slope (extending from the NF area to the breakpoint) to an increasing trend for the second slope (extending from the breakpoint through MF3-7).

Concentrations of TSS, TDS, calcium, chloride, sodium, and sulphate were generally lower at LDS-4 compared to most stations located in Lac de Gras, whereas concentrations of magnesium and potassium were generally similar at LDS-4 compared to concentrations measured in Lac de Gras. Turbidity was greater at LDS-4 than at most of the stations in Lac de Gras. During the ice-cover season, concentrations of most SOIs at LDG-48 were slightly greater than those encountered at the far end of the MF3 transect (i.e., MF3-7) whereas concentrations at LDG-48 were generally similar those at the far end of the MF3 transect in the open-water season.

Table 3-10 Gradient Analysis for Conventional Variables, Total Dissolved Solids, and Associated Ions, 2020

Variable	Season	Model	Trans-formation[a]	Gradient	Slope Direction[b]	Break-point (km)[c]	*P*-value[d]	R^2 or r^2[e]
Turbidity	Ice-cover	n/a						
	Open-water	n/a						
Total Suspended Solids	Ice-cover	n/a						
	Open-water	n/a						
Total Dissolved Solids, calculated	Ice-cover	Model 2	log	MF1	↓	-	**<0.001**	0.79
				MF2	↓	-	**<0.001**	
		Model 3		MF3 (1st slope)	↓	4.5	**<0.001**	0.98
				MF3 (2nd slope)	↓		-	
	Open-water	Model 1	log	MF1	↓	-	**<0.001**	0.64
				MF2	↓	-	0.904	
				MF3	↓	-	**<0.001**	
Calcium (total)	Ice-cover	Model 2	log	MF1	↓	-	**0.002**	0.78
				MF2	↓	-	**<0.001**	
		Model 3		MF3 (1st slope)	↓	4.4	**<0.001**	0.96
				MF3 (2nd slope)	↓		-	
	Open-water[f]	Model 2	0.5	MF1	↓	-	**0.001**	0.57
				MF2	↓	-	0.059	
		Model 3		MF3 (1st slope)	↓	4.3	**<0.001**	0.95
				MF3 (2nd slope)	↓		-	
Chloride	Ice-cover	Model 2	log	MF1	↓	-	**<0.001**	0.66
				MF2	↓	-	**0.001**	
		Model 3		MF3 (1st slope)	↓	4.2	**<0.001**	0.98
				MF3 (2nd slope)	↓		-	
	Open-water	Model 2	none	MF1	↓	-	**<0.001**	0.60
				MF2	↓	-	0.29	
		Model 3		MF3 (1st slope)	↓	3.3	**0.006**	0.89
				MF3 (2nd slope)	↓		-	
Magnesium (total)	Ice-cover	Model 2	none	MF1	↓	-	**0.001**	0.58
				MF2	↓	-	**0.021**	
		Model 3		MF3 (1st slope)	↓	4.3	**<0.001**	0.95
				MF3 (2nd slope)	↓		-	
	Open-water[g]	Model 2	log	MF1	↓	-	**0.001**	0.56
				MF2	↓	-	**0.011**	
		Model 3		MF3 (1st slope)	↓	5.6	**0.004**	0.89
				MF3 (2nd slope)	↑		-	
Potassium (total)	Ice-cover	Model 1	log	MF1	↓	-	**0.006**	0.45
				MF2	↓	-	0.055	
				MF3	↓	-	**0.002**	
	Open-water[h]	Model 2	log	MF1	↓	-	**<0.001**	0.61
				MF2	↓	-	**0.013**	
		Model 3		MF3 (1st slope)	↓	4.8	**0.001**	0.91
				MF3 (2nd slope)	↓		-	
Sodium (total)	Ice-cover	Model 2	log	MF1	↓	-	**0.002**	0.80
				MF2	↓	-	**<0.001**	
		Model 3		MF3 (1st slope)	↓	4.8	**<0.001**	0.98
				MF3 (2nd slope)	↓		-	
	Open-water[i]	Model 2	log	MF1	↓	-	**<0.001**	0.79
				MF2	↓	-	**0.001**	
		Model 3		MF3 (1st slope)	↓	5.3	**<0.001**	0.96
				MF3 (2nd slope)	↓		-	
Sulphate	Ice-cover	Model 1	none	MF1	↓	-	**<0.001**	0.79
				MF2	↓	-	**<0.001**	
				MF3	↓	-	**<0.001**	
	Open-water	Model 1	log	MF1	↓	-	**0.003**	0.42
				MF2	↓	-	**0.036**	
				MF3	↓	-	**0.008**	

a) Models used and transformation rules are described in Section 2.4.5.2

b) Slope direction was represented by an upward arrow (↑) indicating an increasing trend with distance from the diffuser, or a downward arrow (↓) indicating a decreasing trend with distance from the diffuser.

c) The breakpoint is the location from the effluent discharge where the slopes of the linear regressions along the MF3 transect changed value.

d) *P*-values were not calculated for the second MF3 slope.

e) For Model 3 (i.e., MF3 broken stick models), r^2 is calculated because there is only one predictor, which is distance; for the other models, R^2 is calculated, since there is more than one predictor, i.e., distance and gradient.

f) Outliers removed: 3.53 mg/L, 2.74 mg/L, and 2.67 mg/L.

g) Outliers removed: 1.85 mg/L, 1.57 mg/L, and 1.53 mg/L.

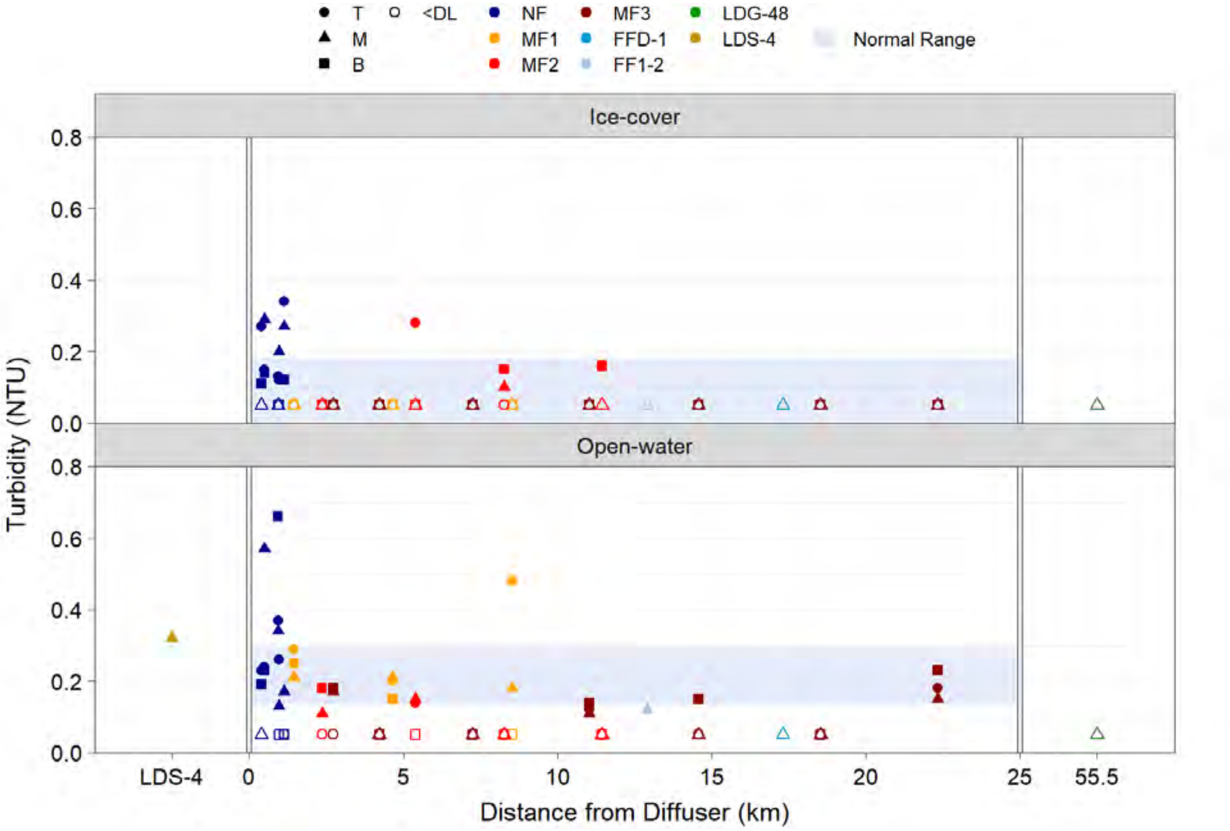
h) Outliers removed: 1.71 mg/L, 1.38 mg/L, and 1.34 mg/L.

i) Outliers removed: 4.03 mg/L, 3 mg/L, and 2.88 mg/L.

Note: **Bold** indicates *P*-value is significant at <0.05.

- = not applicable; MF = mid-field.

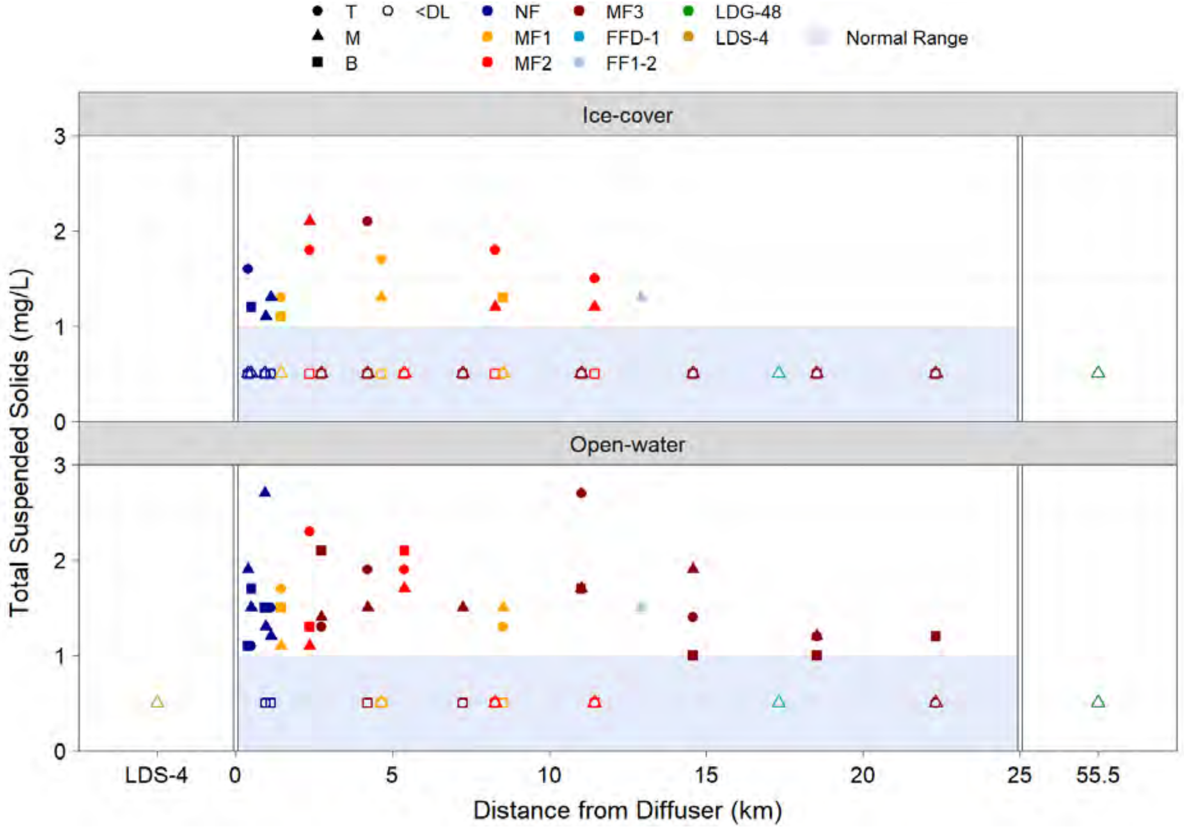
Figure 3-33 Turbidity According to Distance from the Effluent Discharge, 2020



Note: Values represent concentrations in individual samples collected at top, middle and bottom depths. Open symbols represent non-detect data. Shaded bands around fitted prediction lines are 95% confidence intervals (back-transformed to original scale of the variable).

T = top depth; M = middle depth; B = bottom depth; x = statistical outlier; NTU = nephelometric turbidity unit; NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage.

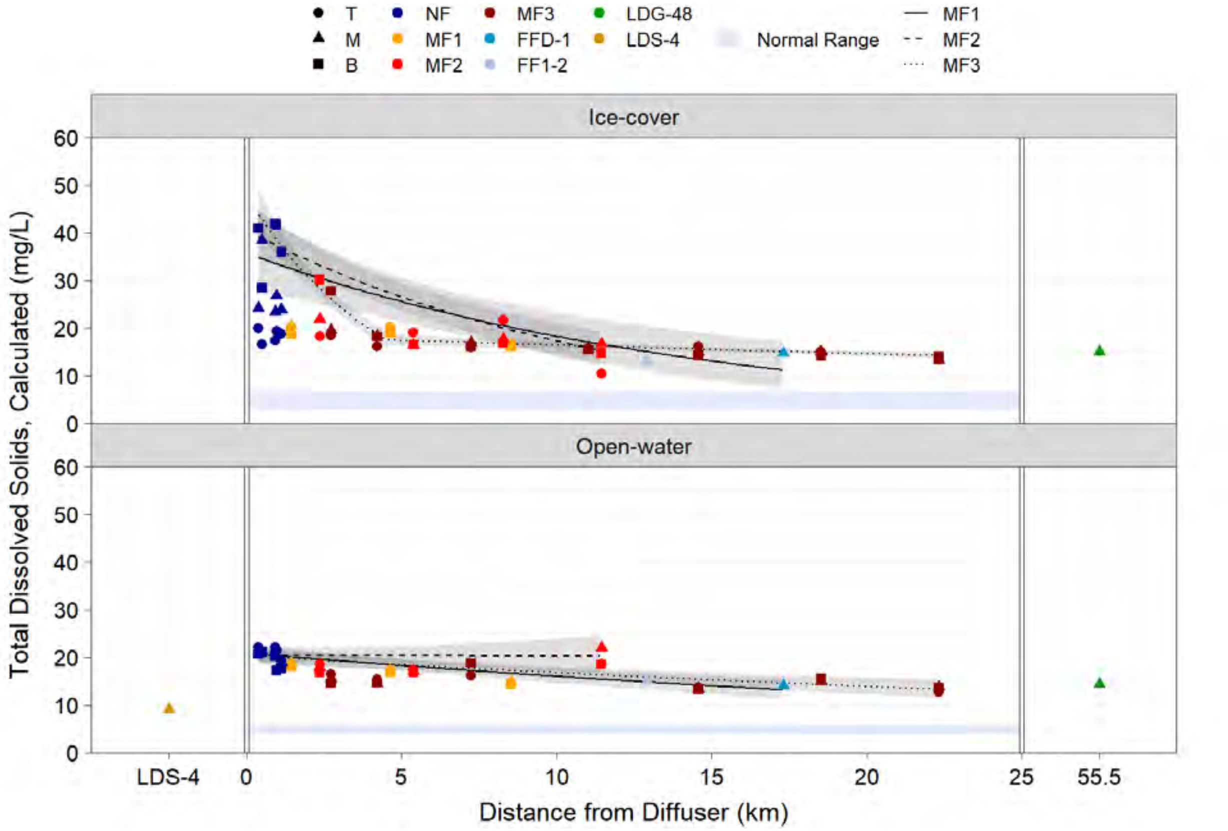
Figure 3-34 Total Suspended Solids According to Distance from the Effluent Discharge, 2020



Note: Values represent concentrations in individual samples collected at top, middle and bottom depths. Open symbols represent non-detect data. Shaded bands around fitted prediction lines are 95% confidence intervals (back-transformed to original scale of the variable).

T = top depth; M = middle depth; B = bottom depth; x = statistical outlier; NTU = nephelometric turbidity unit; NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage.

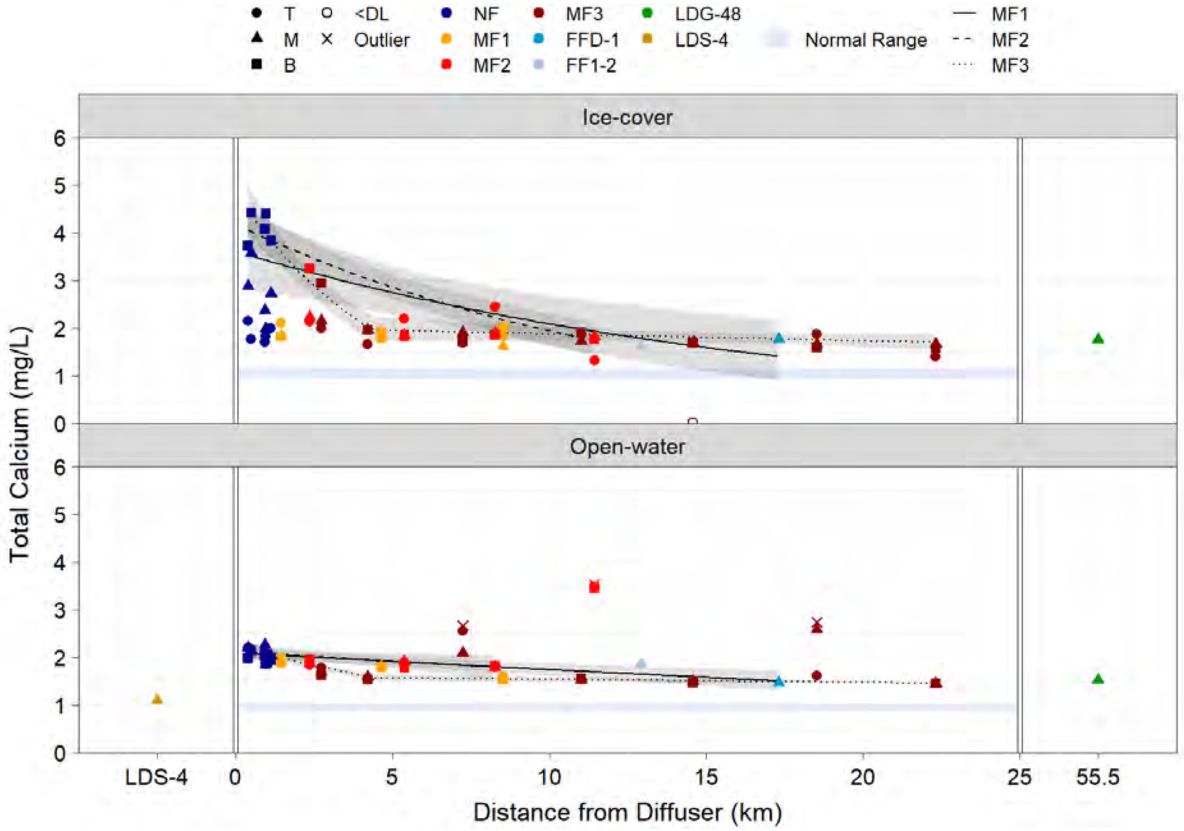
Figure 3-35 Concentrations of Total Dissolved Solids (Calculated) According to Distance from the Effluent Discharge, 2020



Note: Values represent concentrations in individual samples collected at top, middle and bottom depths. Open symbols represent non-detect data. Shaded bands around fitted prediction lines are 95% confidence intervals (back-transformed to original scale of the variable).

T = top depth; M = middle depth; B = bottom depth; NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage.

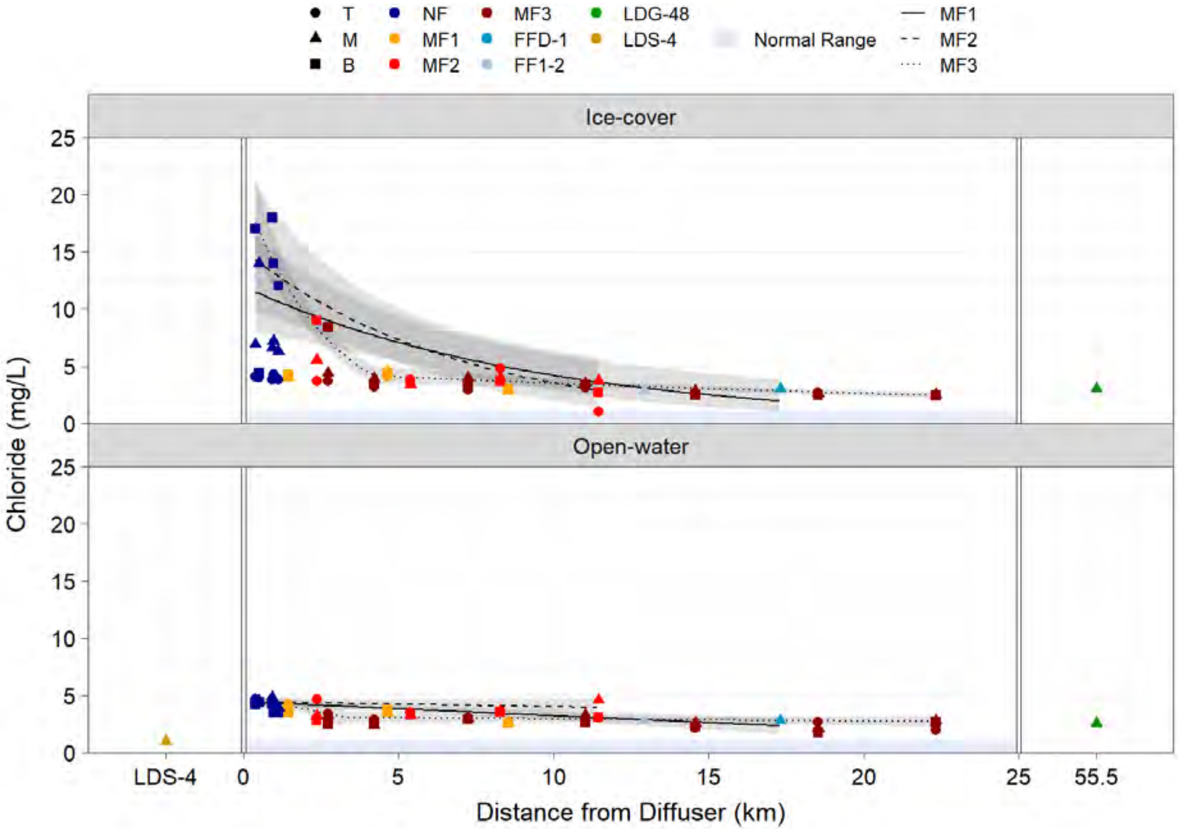
Figure 3-36 Concentrations of Calcium (Total) According to Distance from the Effluent Discharge, 2020



Note: Values represent concentrations in individual samples collected at top, middle and bottom depths. Open symbols represent non-detect data. Shaded bands around fitted prediction lines are 95% confidence intervals (back-transformed to original scale of the variable).

T = top depth; M = middle depth; B = bottom depth; NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage

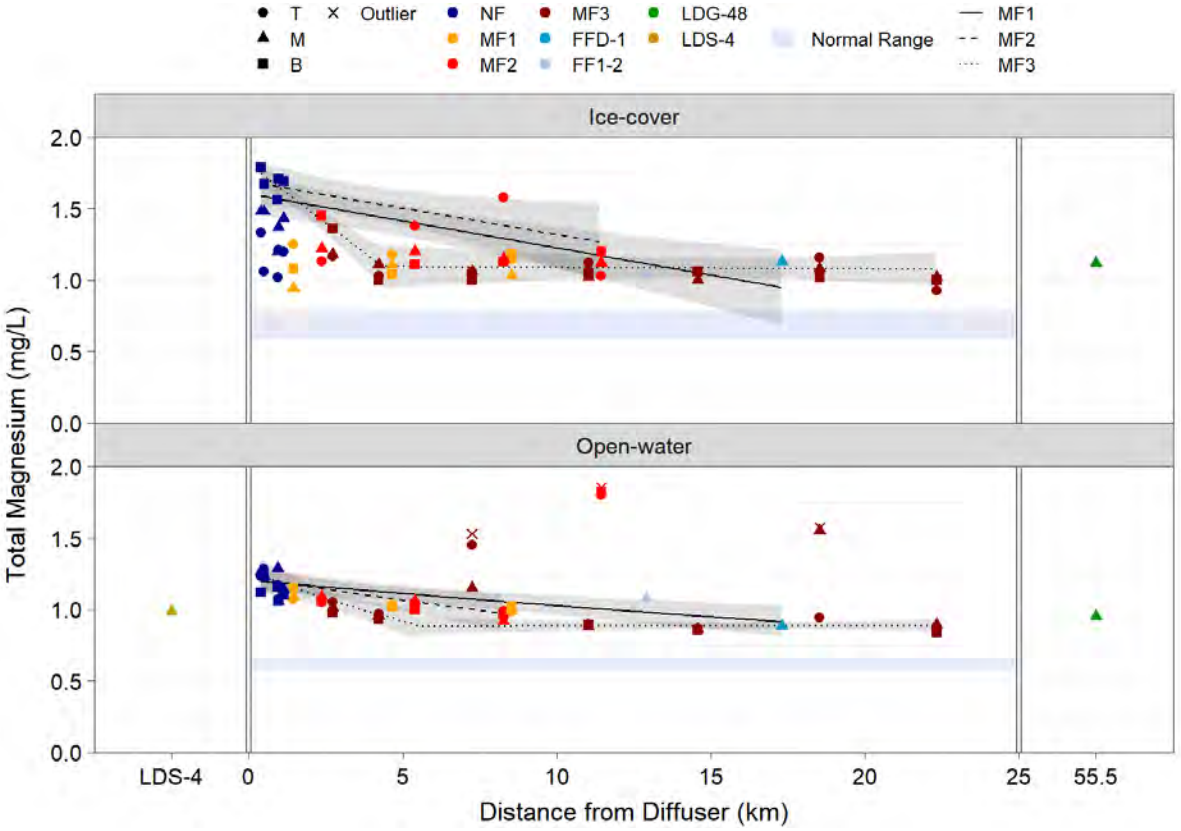
Figure 3-37 Concentration of Chloride According to Distance from the Effluent Discharge, 2020



Note: Values represent concentrations in individual samples collected at top, middle and bottom depths. Open symbols represent non-detect data. Shaded bands around fitted prediction lines are 95% confidence intervals (back-transformed to original scale of the variable).

T = top depth; M = middle depth; B = bottom depth; <DL = less than detection limit; x = statistical outlier; NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage.

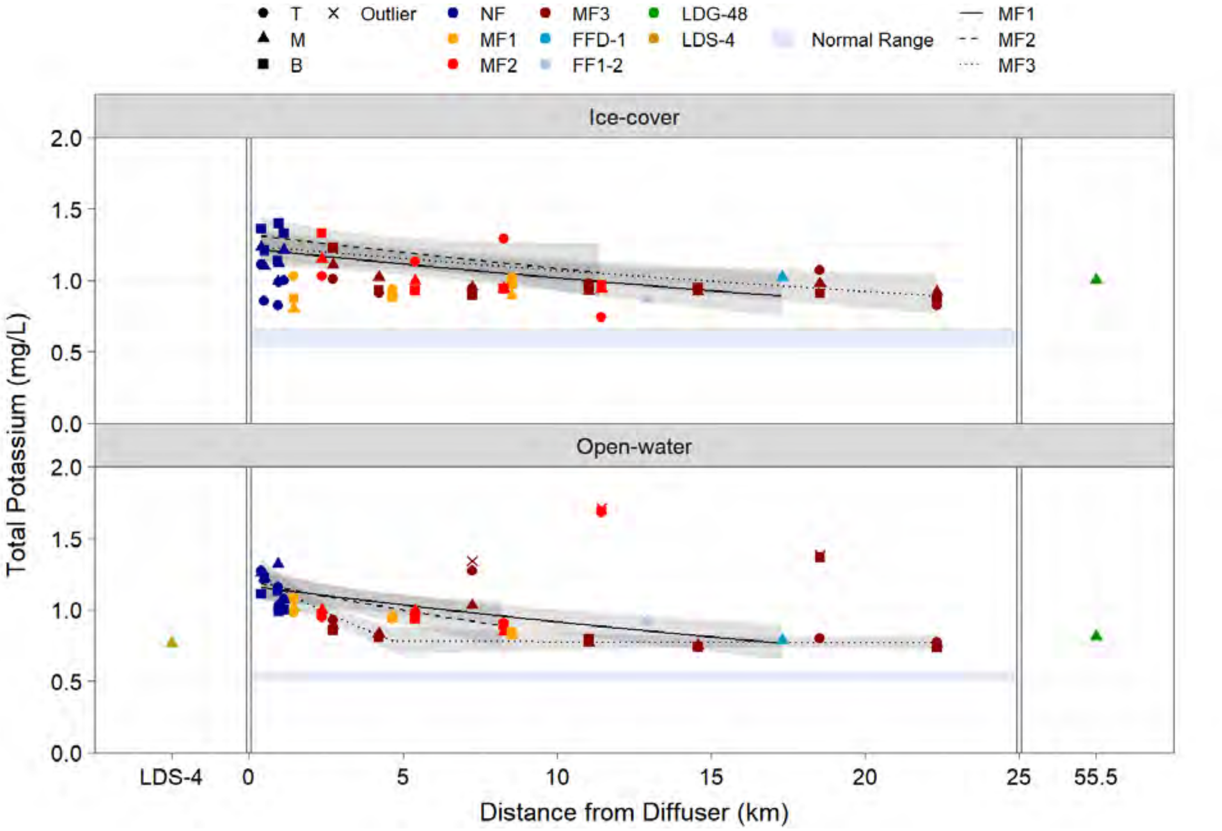
Figure 3-38 Concentrations of Magnesium (Total) According to Distance from the Effluent Discharge, 2020



Note: Values represent concentrations in individual samples collected at top, middle and bottom depths. Open symbols represent non-detect data. Shaded bands around fitted prediction lines are 95% confidence intervals (back-transformed to original scale of the variable).

T = top depth; M = middle depth; B = bottom depth; NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage.

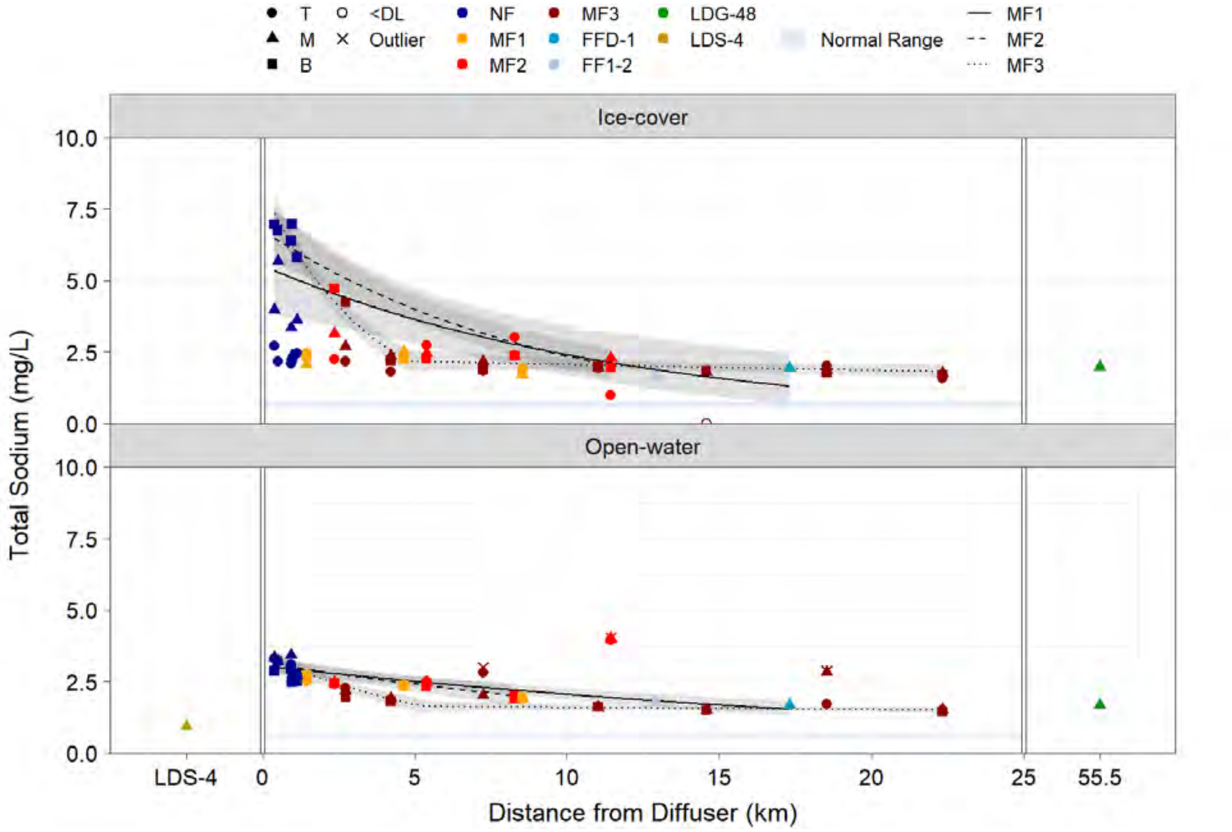
Figure 3-39 Concentration of Potassium (Total) According to Distance from the Effluent Discharge, 2020



Note: Values represent concentrations in individual samples collected at top, middle and bottom depths. Open symbols represent non-detect data. Shaded bands around fitted prediction lines are 95% confidence intervals (back-transformed to original scale of the variable).

T = top depth; M = middle depth; B = bottom depth; NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage.

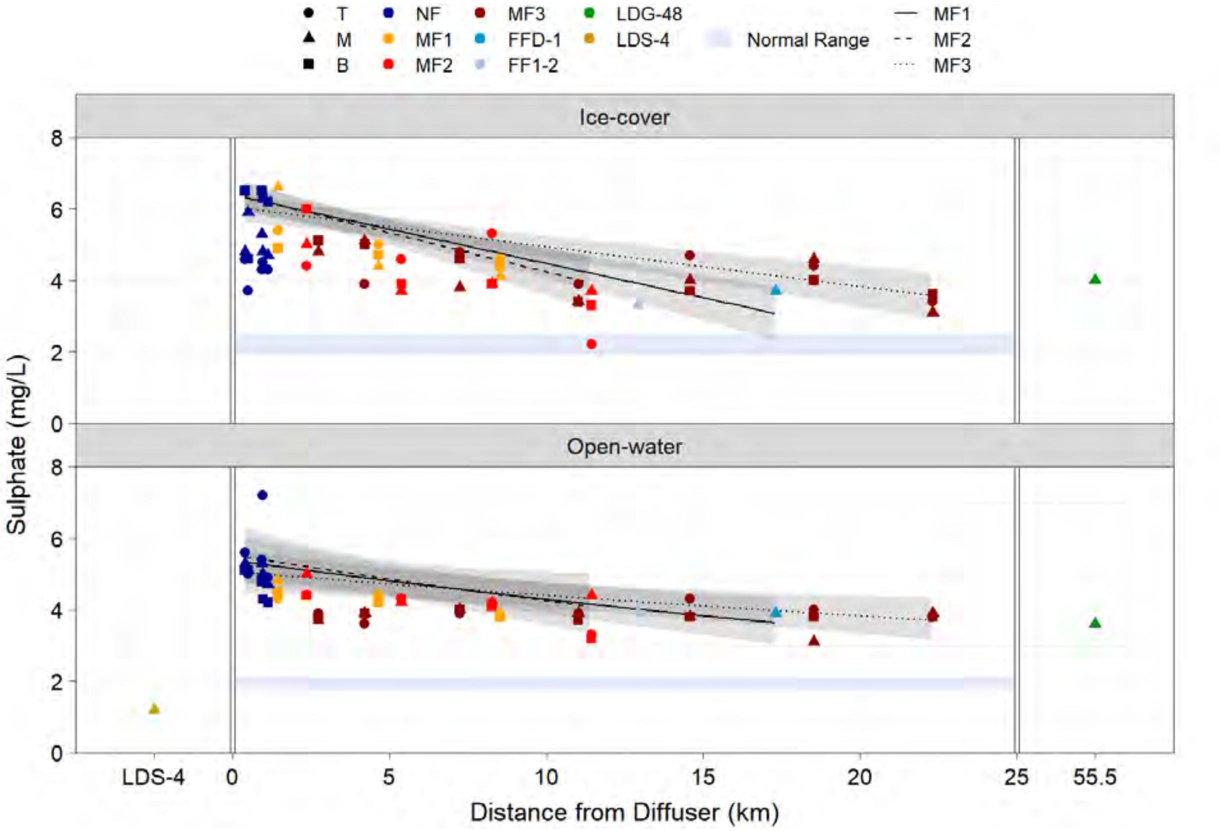
Figure 3-40 Concentration of Sodium (Total) According to Distance from the Effluent Discharge, 2020



Note: Values represent concentrations in individual samples collected at top, middle and bottom depths. Open symbols represent non-detect data. Shaded bands around fitted prediction lines are 95% confidence intervals (back-transformed to original scale of the variable).

T = top depth; M = middle depth; B = bottom depth; NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage.

Figure 3-41 Concentration of Sulphate According to Distance from the Effluent Discharge, 2020



Note: Values represent concentrations in individual samples collected at top, middle and bottom depths. Open symbols represent non-detect data. Shaded bands around fitted prediction lines are 95% confidence intervals (back-transformed to original scale of the variable).

T = top depth; M = middle depth; B = bottom depth; NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage.

3.6.2 Nitrogen Variables

The slopes of the linear regressions for ammonia were significantly different from zero for the MF1 transect in both seasons, and for the MF3 transect in the ice-cover season (Table 3-11). These slopes were negative, indicating decreasing concentrations with distance from the effluent discharge. The spatial analysis of the MF3 transect during open-water identified a breakpoint at 1.6 km from the effluent discharge.

The statistical analysis of nitrate concentration along the MF1, MF2, and MF3 transects was restricted to the ice-cover season, due to high censoring of datasets during open-water conditions (Section 2.4.5.2). Nitrate had significant decreasing trends with distance from the diffuser along all three MF transects during the ice-cover season (Table 3-11). The spatial analysis of the MF3 transect for nitrate detected a breakpoint at 4.5 km from the effluent discharge. During open-water, concentrations of nitrate were elevated (based on a visual assessment) at stations closest to the diffuser, but were less than the DL at stations farther away from the effluent discharge.

Open-water concentrations of ammonia and nitrate at LDS-4 were generally similar to those in Lac de Gras (Figure 3-42 and Figure 3-43). Concentrations of ammonia and nitrate at LDG-48 were similar to those in the MF3-7 area during both seasons.

Table 3-11 Gradient Analysis for Nitrogen Variables, 2020

Variable	Season	Model	Transformation(a)	Gradient	Slope(b)	Breakpoint (km)(c)	*P*-value(d)	R^2 or r^2(e)
Ammonia	Ice-cover(f)	Model 2	log	MF1	↓	-	**0.003**	0.40
				MF2	↓	-	0.357	
		Model 3		MF3 (1st slope)	↓	1.6	**0.044**	0.84
				MF3 (2nd slope)	↓		-	
	Open-water	Model 1	log	MF1	↓	-	**0.014**	0.19
				MF2	↓	-	0.500	
				MF3	↓	-	0.148	
Nitrate	Ice-cover	Model 2	none	MF1	↓	-	**<0.001**	0.82
				MF2	↓	-	**<0.001**	
		Model 3		MF3 (1st slope)	↓	4.5	**0.001**	0.93
				MF3 (2nd slope)	↓		-	
	Open-water	n/a						

a) Models used and transformation rules are described in Section 2.4.5.2

b) Slope direction was represented by an upward arrow (↑) indicating increasing trend with distance from the diffuser, or a downward arrow (↓) indicating a decreasing trend with distance from the diffuser.

c) The breakpoint is the location from the effluent discharge where the slopes of the linear regressions along the MF3 transect changed value.

d) *P*-values were not calculated for the second MF3 slope.

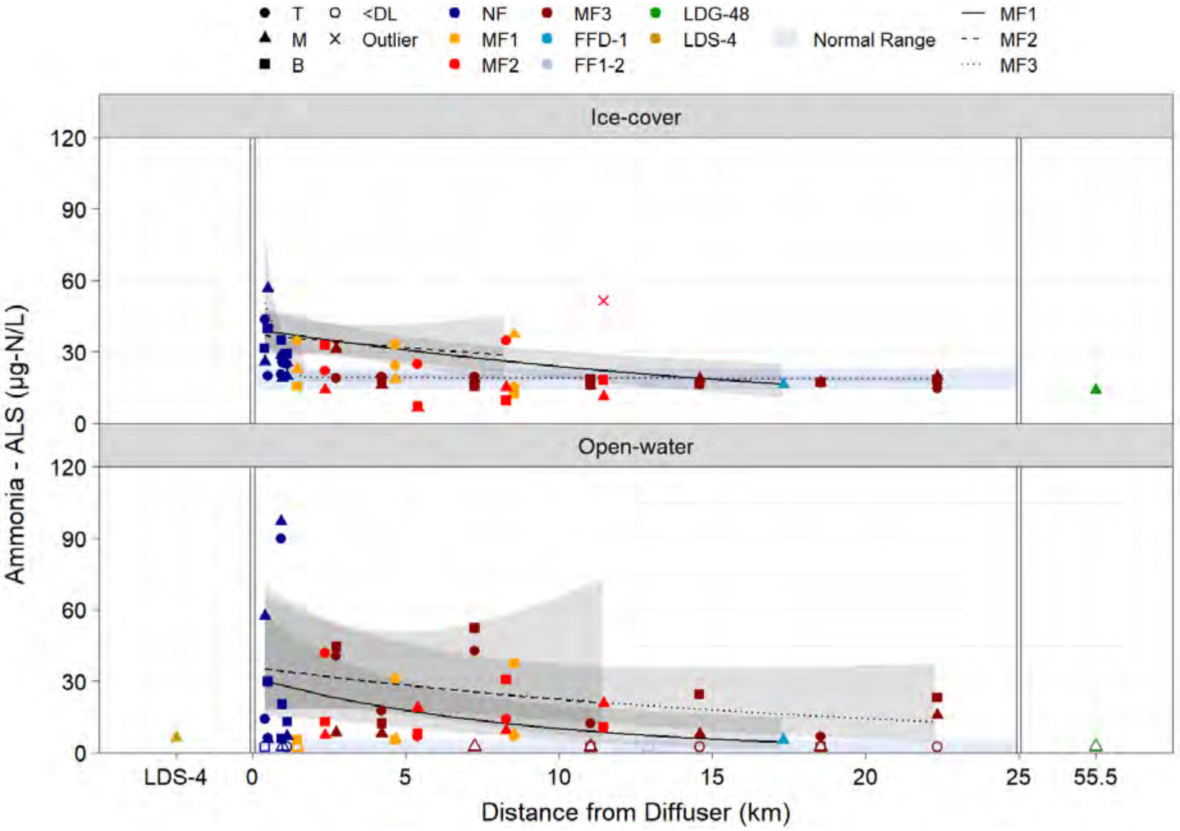
e) For Model 3 (i.e., MF3 broken stick models), r^2 is calculated because there is only one predictor, which is distance; for the other models, R^2 is calculated, since there is more than one predictor, i.e., distance and gradient.

f) Outlier removed: 51.4 µg-N/L.

Note: **Bold** indicates *P*-value is significant at <0.05.

- = not applicable; n/a = not analyzed; MF = mid-field.

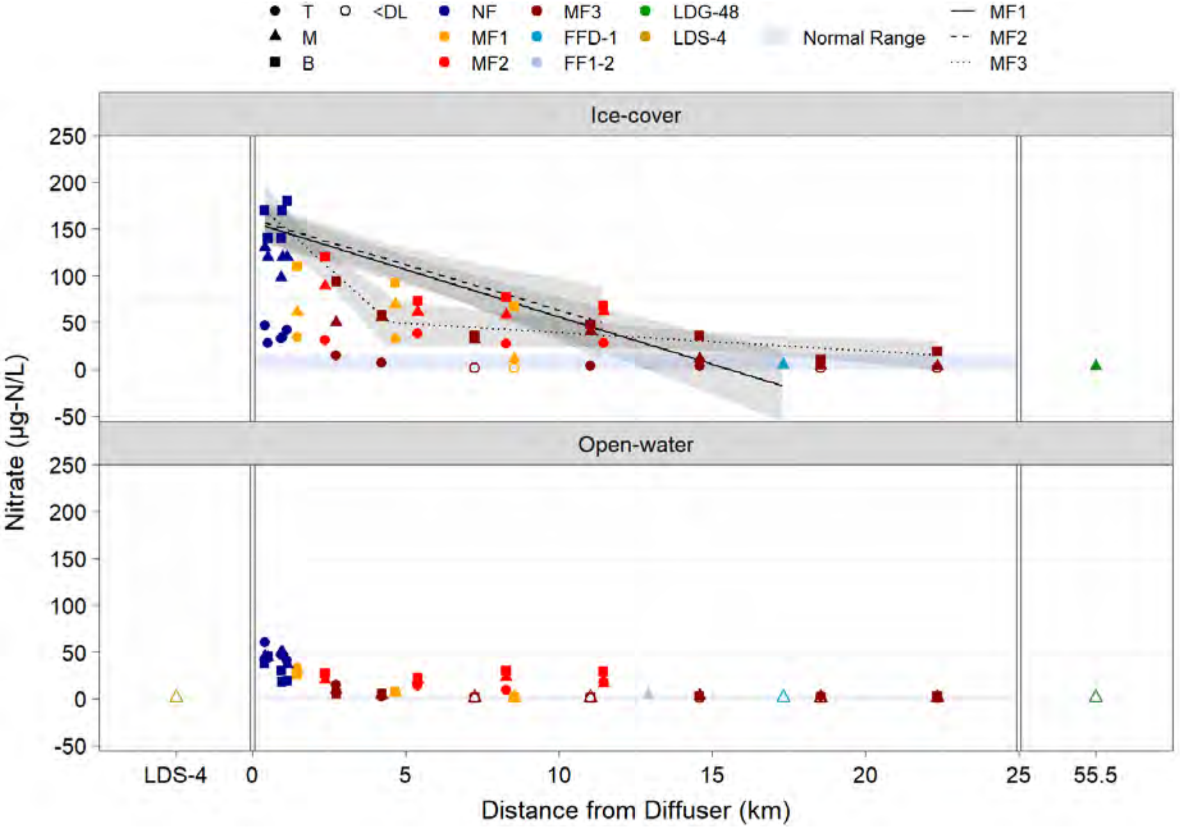
Figure 3-42 Concentrations of Ammonia According to Distance from the Effluent Discharge, 2020



Note: Values represent concentrations in individual samples collected at top, middle and bottom depths. Open symbols represent non-detect data. Shaded bands around fitted prediction lines are 95% confidence intervals (back-transformed to original scale of the variable).

T = top depth; M = middle depth; B = bottom depth; <DL = less than detection limit; µg-N/L = micrograms of nitrogen per litre; NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage.

Figure 3-43 Concentrations of Nitrate According to Distance from the Effluent Discharge, 2020



Note: Values represent concentrations in individual samples collected at top, middle and bottom depths. Open symbols represent non-detect data. Shaded bands around fitted prediction lines are 95% confidence intervals (back-transformed to original scale of the variable).

T = top depth; M = middle depth; B = bottom depth; <DL = less than detection limit; µg-N/L = micrograms of nitrogen per litre; NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage.

3.6.3 Total Metals

The total metal SOIs for which linear regression analysis was completed consisted of aluminum, barium, copper, molybdenum, strontium, sulphur, and uranium (Figure 3-44, Figure 3-46, Figure 3-48, Figure 3-49, and Figure 3-51 to Figure 3-53). Linear regressions were not performed for antimony (both seasons; Figure 3-45), chromium (both seasons; Figure 3-47), and silicon (both seasons; Figure 3-50), due to the considerations discussed in Section 2.4.5.2; however, spatial trends are discussed qualitatively herein.

During the ice-cover season, concentrations of nearly all total metals decreased significantly with distance from the diffuser along all three MF transects (Table 3-12). The exception was the slope for copper, which was only significantly different from zero along the MF2 transect. The slope for copper was positive along the MF2 transect, indicating increasing concentrations with distance from the effluent discharge, which is inconsistent with a Mine-related effect.

During the open-water season, slopes of the majority of the linear regressions were significantly different from zero along all three MF transects. The exceptions were aluminum (which had significant regressions along the MF2 and MF3 transects only), copper (which had non-significant slopes along all three MF transects), and sulphur (which had significant regressions along the MF1 and MF3 transects only). In most cases, slopes were negative, indicating decreasing concentrations with distance from the effluent discharge. However, slopes of linear regressions were positive in direction along all three MF transects for aluminum, indicating increasing concentrations with distance from the effluent discharge. The elevated concentrations along the MF2 transect reflect the influence of the inflow to Lac de Gras from Lac du Sauvage. Concentrations of aluminum at LDS-4were similar to those measured at the end of the MF2 transect.

Piecewise regression was used for the analysis of the MF3 transect for all total metals, with the exception of aluminum (open-water), copper (both seasons), molybdenum (open-water), and uranium (open-water), which used a standard linear approach. Breakpoints identified by the piecewise analysis generally occurred between 4.0 and 5.5 km from the effluent discharge. The exception was sulphur during the open-water season, which had a breakpoint at approximately 12.1 km from the effluent discharge. The trend direction for aluminum in the ice-cover season, and sulphur in both seasons, changed from a decreasing trend for the first slope (extending from the NF area to the breakpoint) to an increasing trend for the second slope (extending from the breakpoint through to MF3-7). The trend direction in other total metal SOIs with significant regressions along the MF3 transect was a decrease in concentration with distance away from the diffusers.

Open-water concentrations of barium, molybdenum, strontium, sulphur, and uranium were generally lower at LDS-4 compared to stations located in Lac de Gras, whereas the concentrations of copper and silicon were slightly greater at LDS-4 compared to stations in Lac de Gras. Concentrations of aluminum, antimony, and chromium were generally similar at LDS-4 compared to concentrations measured in Lac de Gras. Concentrations of most total metal SOIs at LDG-48 were similar to those encountered at MF3-7 during both seasons. The exceptions were antimony (ice-cover), chromium (open-water), copper (both seasons), silicon (open-water), and sulphur (open-water), which had greater concentrations at LDG-48 than at MF3-7.

Table 3-12 Gradient Analysis for Total Metals, 2020

Variable	Season	Model	Transformation(a)	Gradient	Slope(b)	Break-point (km)(c)	*P*-value(d)	R^2 or r^2(e)
Aluminum	Ice-cover	Model 2	log	MF1	↓	-	**0.039**	0.39
				MF2	↓	-	**0.010**	
		Model 3		MF3 (1st slope)	↓	4.8	**0.004**	0.78
				MF3 (2nd slope)	↑		-	
	Open-water	Model 1	0.5	MF1	↑	-	0.133	0.54
				MF2	↑	-	**<0.001**	
				MF3	↑	-	**0.001**	
Antimony	Ice-cover	n/a						
	Open-water	n/a						
Barium	Ice-cover	Model 2	0.5	MF1	↓	-	**0.009**	0.75
				MF2	↓	-	**<0.001**	
		Model 3		MF3 (1st slope)	↓	4.2	**<0.001**	0.97
				MF3 (2nd slope)	↓		-	
	Open-water(f)	Model 2	log	MF1	↓	-	**<0.001**	0.74
				MF2	↓	-	**0.006**	
		Model 3		MF3 (1st slope)	↓	4.9	**<0.001**	0.95
				MF3 (2nd slope)	↓		-	
Chromium	Ice-cover	n/a						
	Open-water	n/a						
Copper	Ice-cover	Model 1	0.5	MF1	↑	-	0.833	0.08
				MF2	↑	-	**0.028**	
				MF3	↓	-	0.714	
	Open-water(g)	Model 1	log	MF1	↑	-	0.512	0.01
				MF2	↓	-	0.577	
				MF3	↓	-	0.185	
Molybdenum	Ice-cover	Model 2	0.5	MF1	↓	-	**<0.001**	0.68
				MF2	↓	-	**0.004**	
		Model 3		MF3 (1st slope)	↓	4.7	**0.001**	0.94
				MF3 (2nd slope)	↓		-	
	Open-water(h)	Model 1	log	MF1	↓	-	**<0.001**	0.91
				MF2	↓	-	**<0.001**	
				MF3	↓	-	**<0.001**	
Silicon	Ice-cover	n/a						
	Open-water	n/a						
Strontium	Ice-cover(i)	Model 2	log	MF1	↓	-	**0.001**	0.63
				MF2	↓	-	**0.003**	
		Model 3		MF3 (1st slope)	↓	4.6	**<0.001**	0.99
				MF3 (2nd slope)	↓		-	
	Open-water(j)	Model 2	log	MF1	↓	-	**<0.001**	0.86
				MF2	↓	-	**0.004**	
		Model 3		MF3 (1st slope)	↓	5.2	**<0.001**	0.97
				MF3 (2nd slope)	↓		-	
Sulphur	Ice-cover(k)	Model 2	0.5	MF1	↓	-	**<0.001**	0.74
				MF2	↓	-	**0.001**	
		Model 3		MF3 (1st slope)	↓	4.2	**0.017**	0.82
				MF3 (2nd slope)	↑		-	
	Open-water(l)	Model 2	log	MF1	↓	-	**<0.001**	0.65
				MF2	↑	-	0.077	
		Model 3		MF3 (1st slope)	↓	12.1	**<0.001**	0.96
				MF3 (2nd slope)	↑		-	
Uranium	Ice-cover	Model 2	log	MF1	↓	-	**<0.001**	0.78
				MF2	↓	-	**<0.001**	
		Model 3		MF3 (1st slope)	↓	4.4	**<0.001**	0.96
				MF3 (2nd slope)	↓		-	
	Open-water(m)	Model 1	log	MF1	↓	-	**<0.001**	0.81
				MF2	↓	-	**<0.001**	
				MF3	↓	-	**<0.001**	

a) Models used and transformation rules are described in Section 2.4.5.2

b) Slope direction was represented by an upward arrow (↑) indicating increasing trend with distance from the diffuser, or a downward arrow (↓) indicating a decreasing trend with distance from the diffuser.

c) The breakpoint is the location from the effluent discharge where the slopes of the linear regressions along the MF3 transect changed value.

d) *P*-values were not calculated for the second MF3 slope.

e) For Model 3 (i.e., MF3 broken stick models), r^2 is calculated because there is only one predictor, which is distance; for the other models, R^2 is calculated, since there is more than one predictor, i.e., distance and gradient.

f) Outliers removed: 4.68 µg/L, 3.66 µg/L, and 3.46 µg/L.

g) Outliers removed: 1.14 µg/L, 0.997 µg/L, and 0.964 µg/L.

h) Outlier removed: 0.987 µg/L.

i) Outlier removed: 46.7 µg/L.

j) Outliers removed: 42.4 µg/L, 27.6 µg/L, and 25.8 µg/L.

k) Outlier removed: 2.73 mg/L.

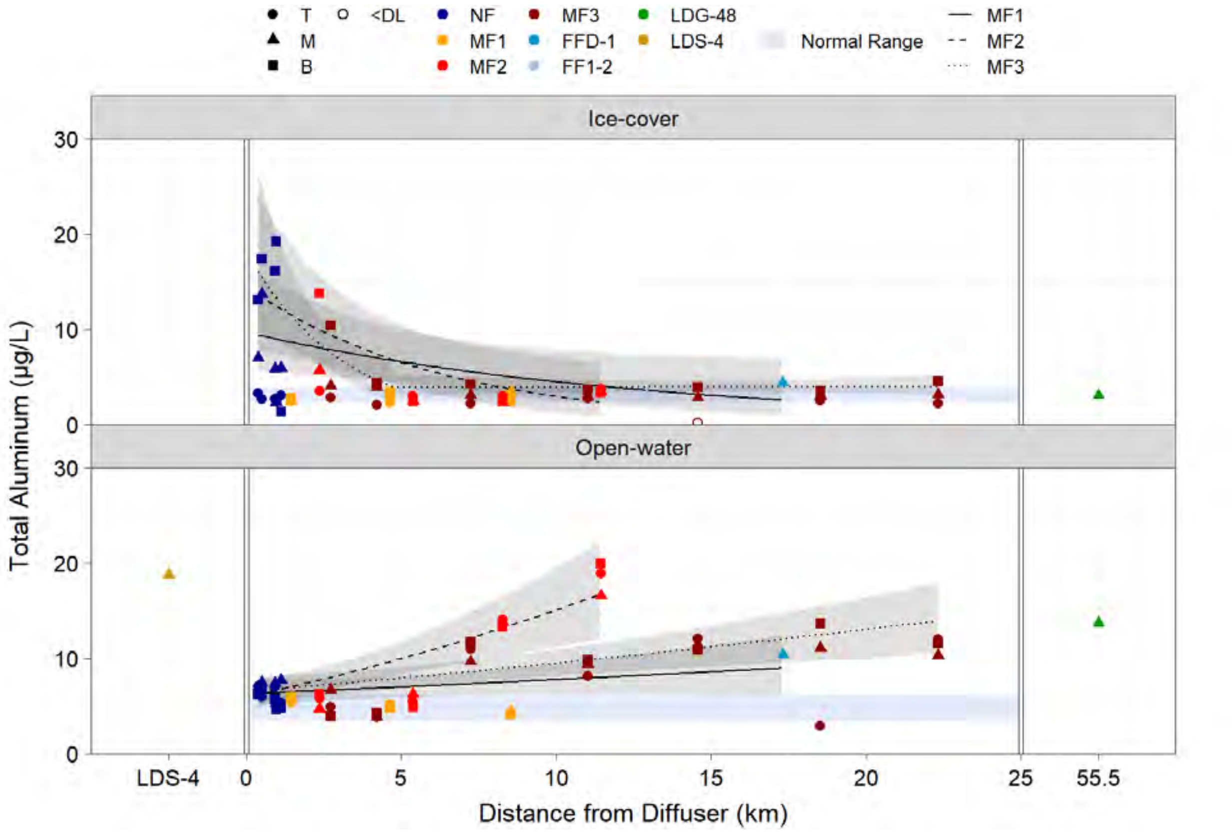
l) Outliers removed: 3.01 mg/L and 2.04 mg/L.

m) Outlier removed: 0.154 µg/L.

Note: **Bold** indicates *P*-value is significant at <0.05.

- = not applicable; n/a = not analyzed; MF = mid-field.

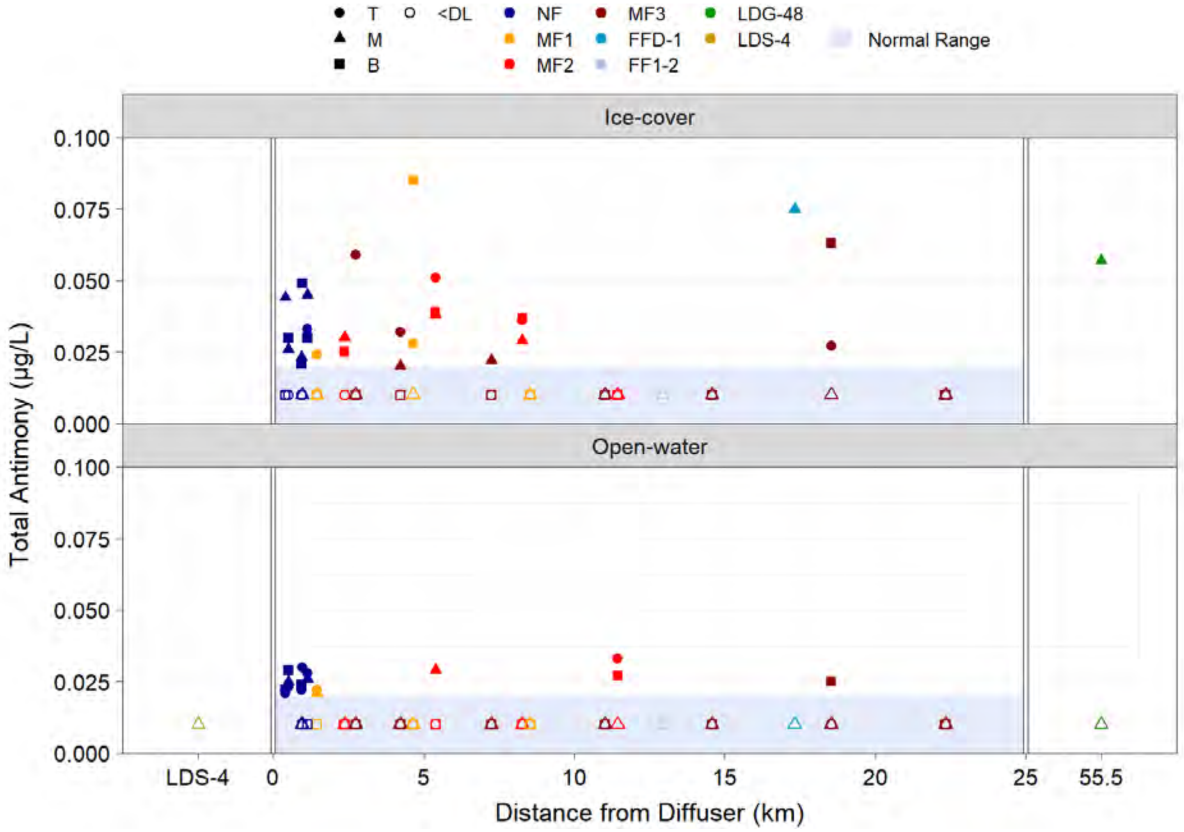
Figure 3-44 **Concentration of Total Aluminum According to Distance from the Effluent Discharge, 2020**



Note: Values represent concentrations in individual samples collected at top, middle and bottom depths. Open symbols represent non-detect data. Shaded bands around fitted prediction lines are 95% confidence intervals (back-transformed to original scale of the variable).

T = top depth; M = middle depth; B = bottom depth; NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage.

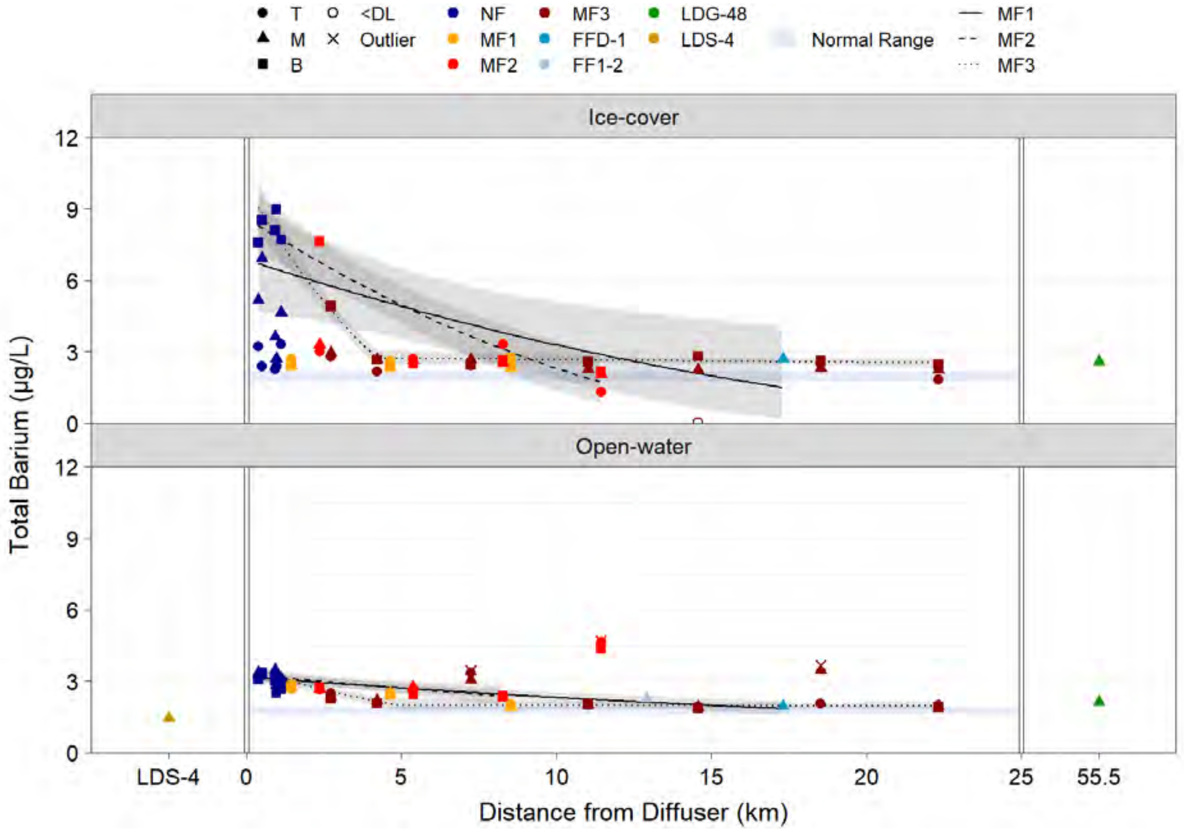
Figure 3-45 Concentration of Total Antimony According to Distance from the Effluent Discharge, 2020



Note: Values represent concentrations in individual samples collected at top, middle and bottom depths. Open symbols represent non-detect data. Shaded bands around fitted prediction lines are 95% confidence intervals (back-transformed to original scale of the variable).

T = top depth; M = middle depth; B = bottom depth; <DL = less than detection limit; NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage.

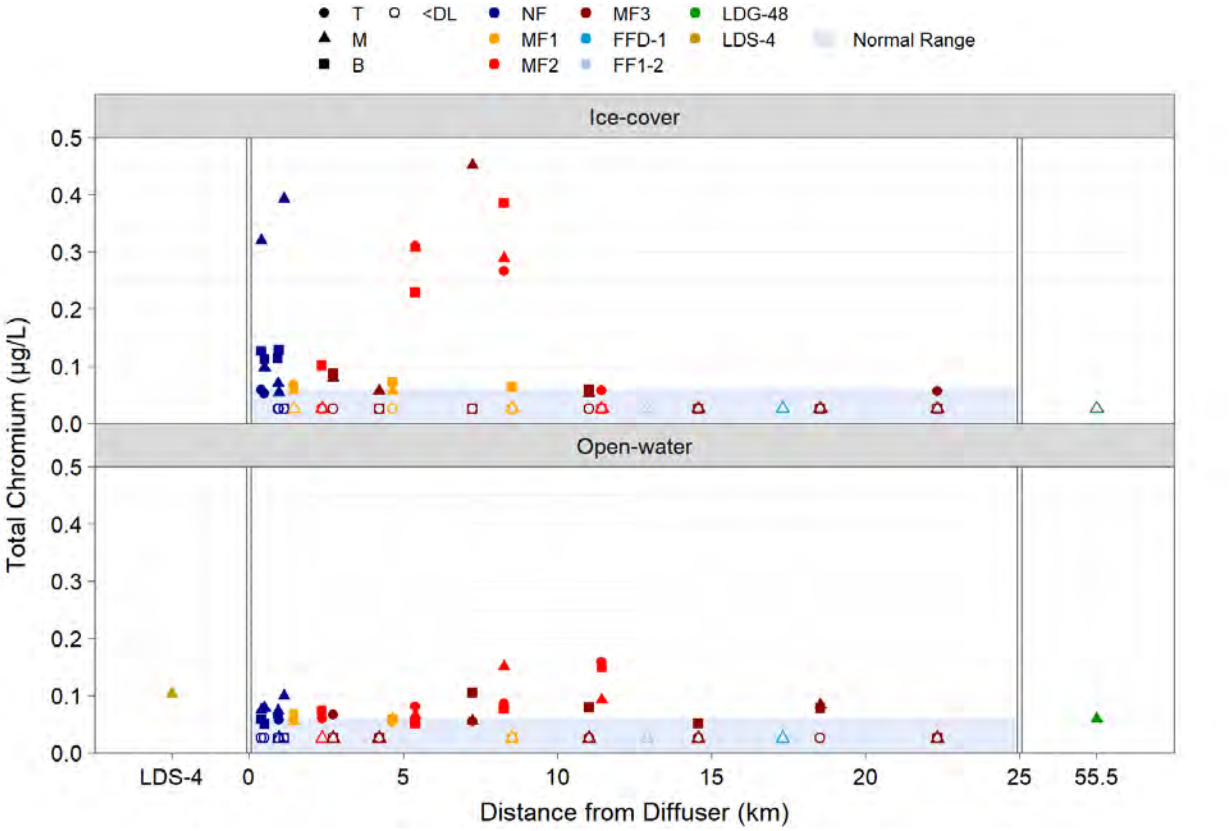
Figure 3-46 Concentration of Total Barium According to Distance from the Effluent Discharge, 2020



Note: Values represent concentrations in individual samples collected at top, middle and bottom depths. Open symbols represent non-detect data. Shaded bands around fitted prediction lines are 95% confidence intervals (back-transformed to original scale of the variable).

T = top depth; M = middle depth; B = bottom depth; <DL = less than detection limit; NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage.

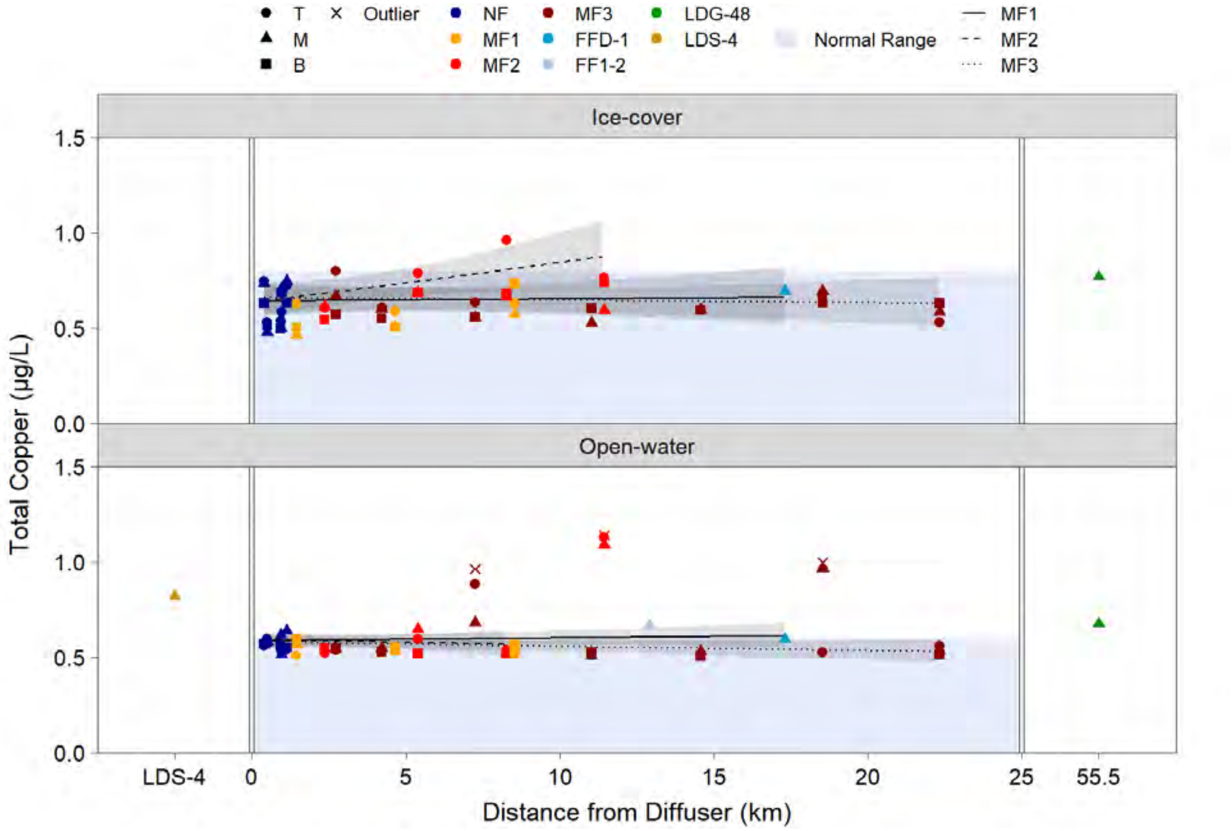
Figure 3-47 Concentration of Total Chromium According to Distance from the Effluent Discharge, 2020



Note: Values represent concentrations in individual samples collected at top, middle and bottom depths. Open symbols represent non-detect data.

T = top depth; M = middle depth; B = bottom depth; x = statistical outlier; NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage.

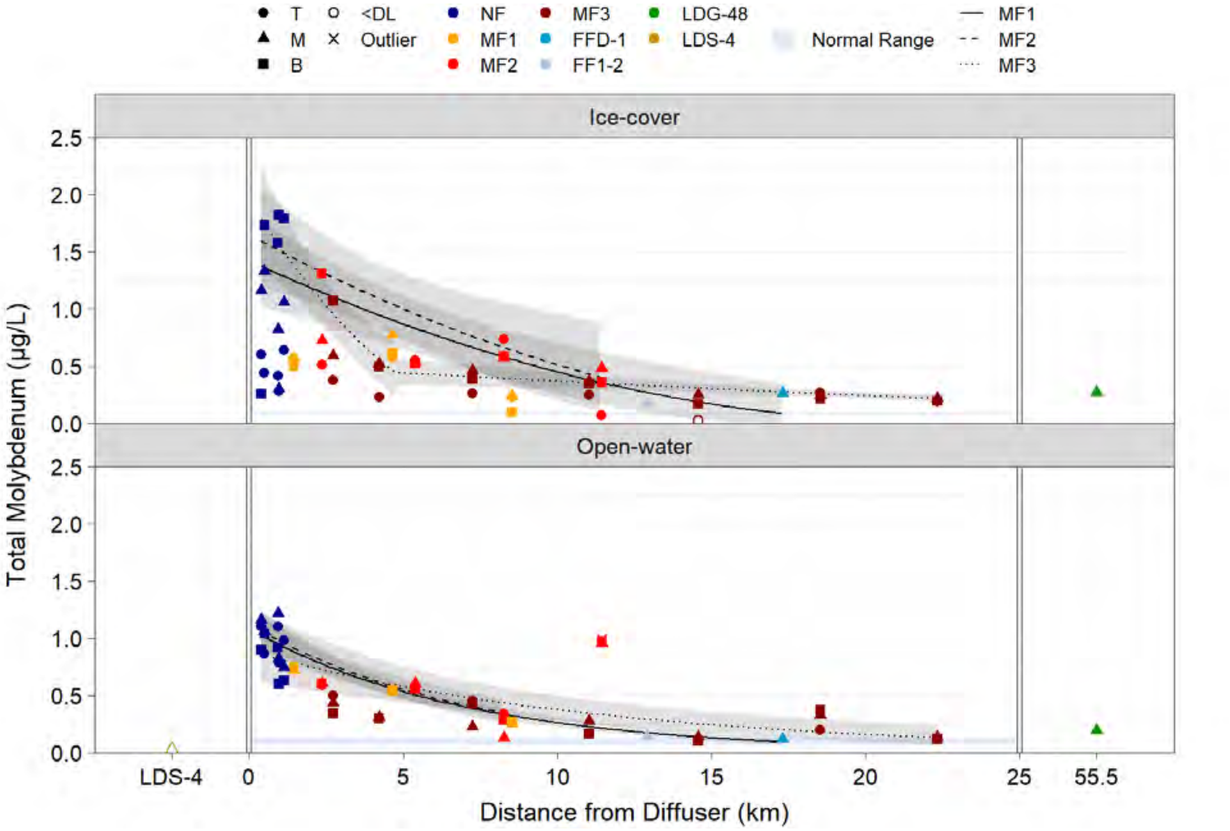
Figure 3-48 Concentration of Total Copper According to Distance from the Effluent Discharge, 2020



Note: Values represent concentrations in individual samples collected at top, middle and bottom depths. Open symbols represent non-detect data.

T = top depth; M = middle depth; B = bottom depth; x = statistical outlier; NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage.

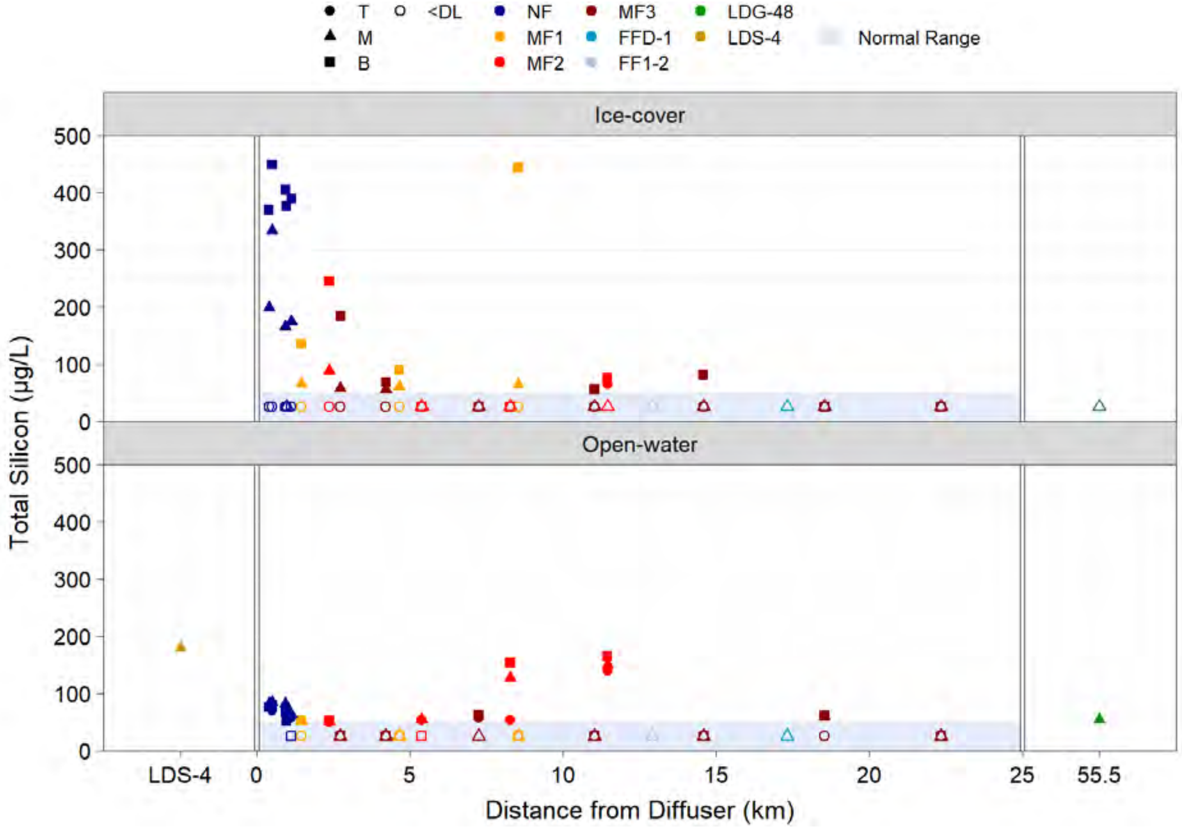
Figure 3-49 **Concentration of Total Molybdenum According to Distance from the Effluent Discharge, 2020**



Note: Values represent concentrations in individual samples collected at top, middle and bottom depths. Open symbols represent non-detect data. Shaded bands around fitted prediction lines are 95% confidence intervals (back-transformed to original scale of the variable).

T = top depth; M = middle depth; B = bottom depth; <DL = less than detection limit; NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage.

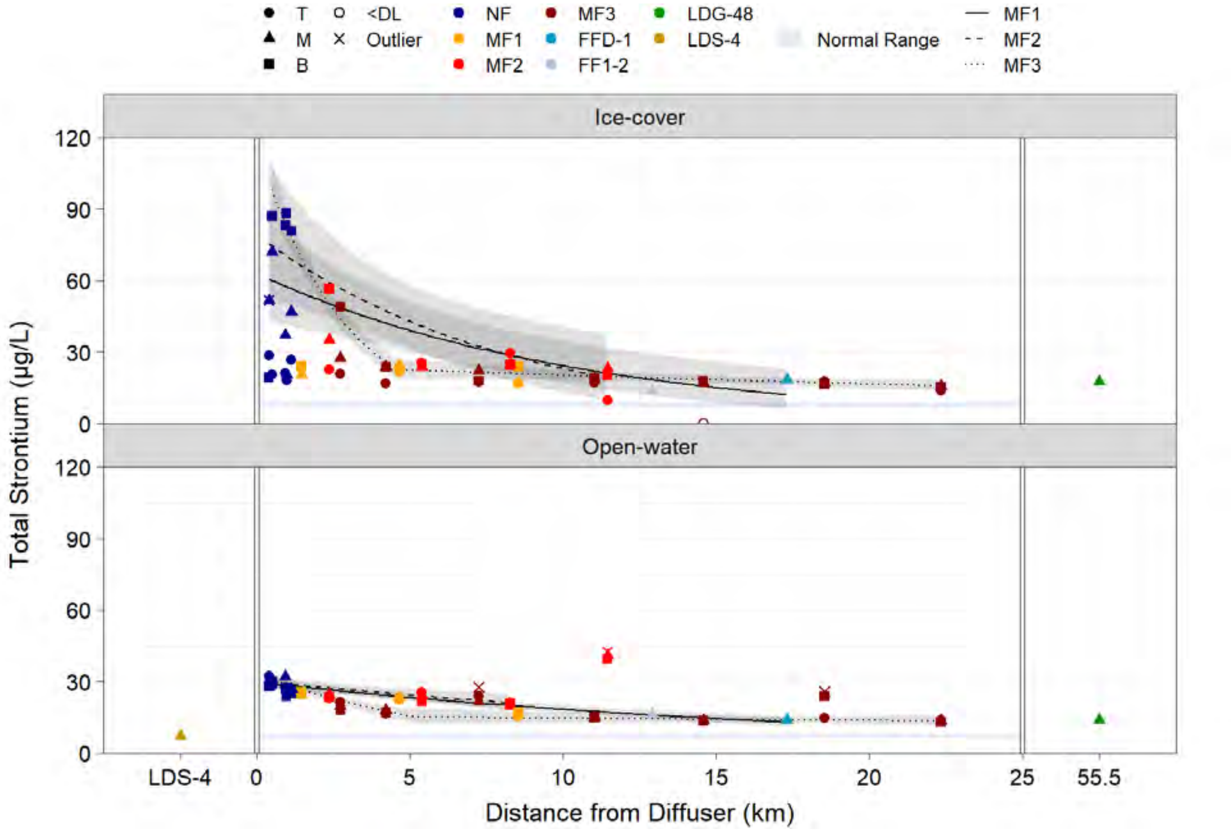
Figure 3-50 Concentration of Total Silicon According to Distance from the Mine Discharge, 2020



Note: Values represent concentrations in individual samples collected at top, middle and bottom depths. Open symbols represent non-detect data.

T = top depth; M = middle depth; B = bottom depth; <DL = less than detection limit; NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage.

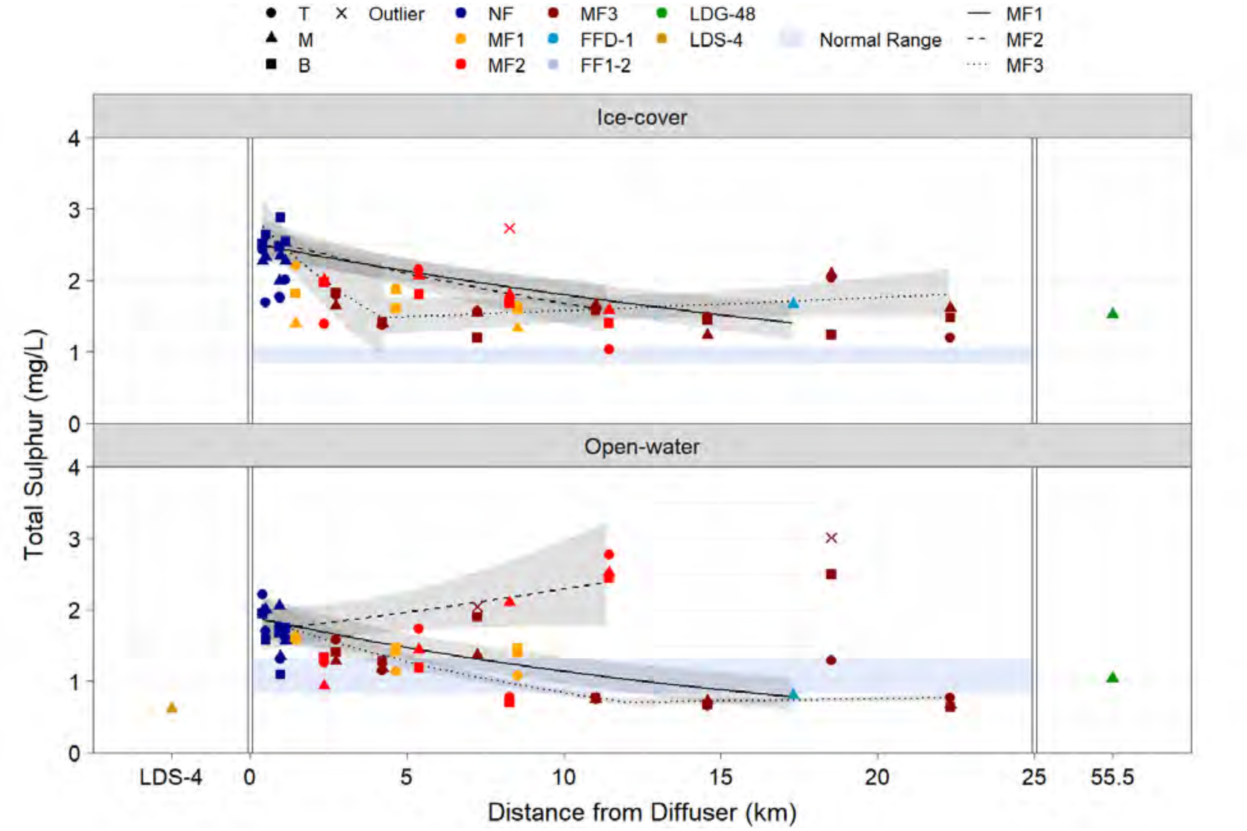
Figure 3-51 **Concentration of Total Strontium According to Distance from the Effluent Discharge, 2020**



Note: Values represent concentrations in individual samples collected at top, middle and bottom depths. Open symbols represent non-detect data. Shaded bands around fitted prediction lines are 95% confidence intervals (back-transformed to original scale of the variable).

T = top depth; M = middle depth; B = bottom depth; NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage.

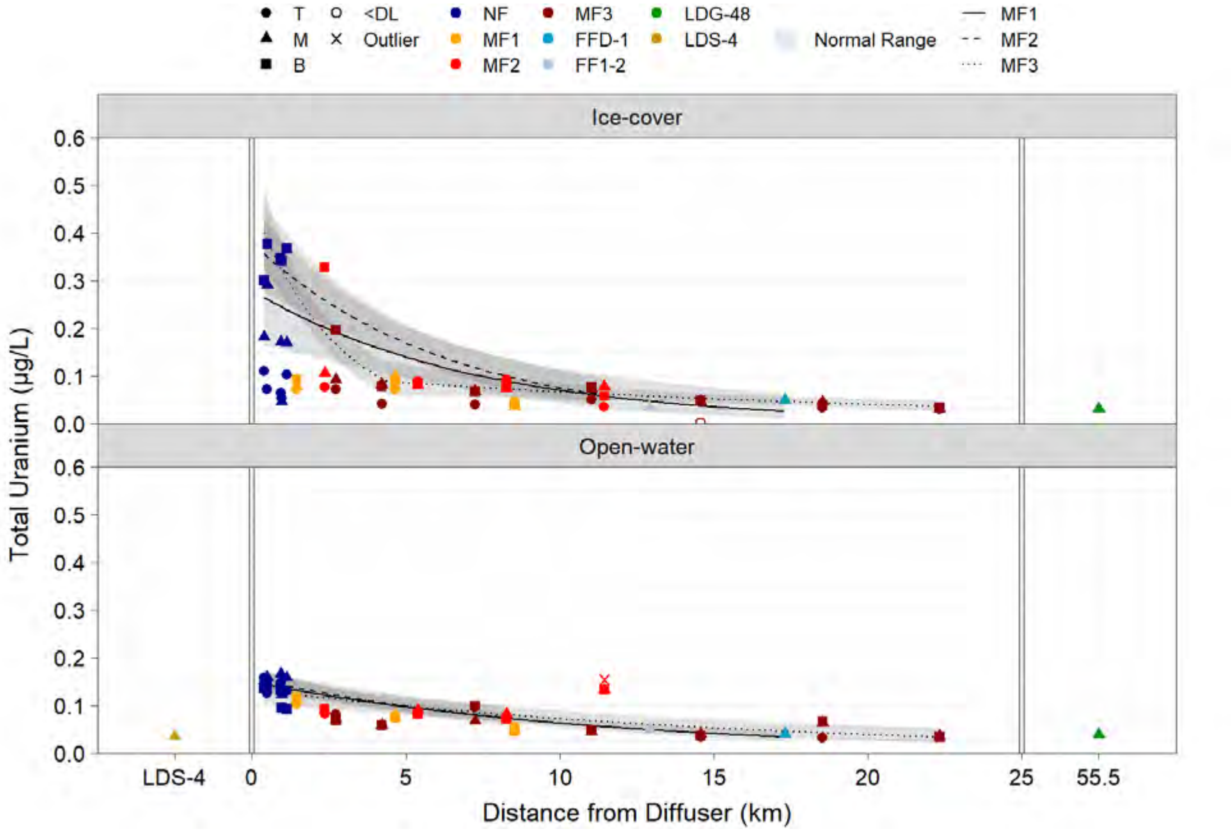
Figure 3-52 **Concentration of Total Sulphur According to Distance from the Effluent Discharge, 2020**



Note: Values represent concentrations in individual samples collected at top, middle and bottom depths. Open symbols represent non-detect data. Shaded bands around fitted prediction lines are 95% confidence intervals (back-transformed to original scale of the variable).

T = top depth; M = middle depth; B = bottom depth; NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage.

Figure 3-53 Concentration of Total Uranium According to Distance from the Effluent Discharge, 2020



Note: Values represent concentrations in individual samples collected at top, middle and bottom depths. Open symbols represent non-detect data. Shaded bands around fitted prediction lines are 95% confidence intervals (back-transformed to original scale of the variable).

T = top depth; M = middle depth; B = bottom depth; NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage.

3.7 Effects from Dust Deposition

In 2020, median concentrations of 25 SOIs met Criterion 4 in the SOI selection process (Section 2.4.1; i.e., TDS, TSS, calcium, chloride, magnesium, potassium, sodium, sulphate, ammonia, nitrate, aluminum, antimony, boron, cobalt, copper, iron, lead, molybdenum, silicon, strontium, sulphur, thallium, tin, uranium, and zinc), because their concentration exceeded two times the median of the reference dataset at one or more of the four MF area stations located within the estimated ZOI from dust deposition (i.e., MF1-1, MF3-1, MF3-2, and MF3-3; Table 3-13). Spatial trends for these variables are shown on Figure 3-54 to Figure 3-62.

Of the 25 SOIs, 18 also triggered Action Level 1 in the NF area (identified by footnote [c] in Table 3-13), indicating that the exceedances of the dust criterion at the MF stations were likely caused by dispersion of Mine effluent into the lake; however, as the NF area is located within the ZOI, there is some potential that dust deposition may also be contributing to the increases observed in these variables in the NF area. Compared to median NF area concentrations, eight SOIs were elevated at one or more of the four MF stations (i.e., TSS, calcium, magnesium, potassium, ammonia, aluminum, copper, and sulphur). These results indicate that the elevated values within the ZOI may not be solely related to dispersion of effluent in the lake. Six of these eight SOIs only exceeded the criterion at MF3-3 (i.e., calcium, magnesium, potassium, aluminum, copper, and sulphur), which is the station within the ZOI that is farthest from the Mine footprint boundary. While there is some potential that these elevated values may be related to dust deposition, such an interpretation is not supported by similar increases at the other stations within the ZOI.

TSS exceeded the criterion at MF1-1, MF3-1, and MF3-2. The median TSS values at all three MF stations were slightly greater than the median reported in the NF area, but concentrations at these stations were similar to those at non-dust affected stations (MF1-2, MF2-1, MF2-2) within the same distance range from the effluent diffuser. While there is some potential that these increases in TSS concentrations may be related to dust deposition, this interpretation is not supported by similar increases in the concentrations of other sediment associated variables such as total metals at these stations.

Concentrations of ammonia exceeded Criterion 4 at MF3-1, MF3-2, and MF3-3. The median concentration at all three MF stations was greater than the median reported in the NF area. In general, nitrogen compounds are not a component of mine dust, but are emitted by mine combustion sources (Golder 2020b). The laboratory quality control issues that have been observed for ammonia indicate that these increases may be due to high variability in the reported concentrations (due to the considerations noted in Section 2.3.1 and Attachment B), rather than a result of dust deposition.

The remaining seven SOIs (i.e., boron, cobalt, iron, lead, thallium, tin, and zinc) exceeded two times the median of the reference dataset value at the four MF stations in the dust deposition ZOI, but did not trigger Action Level 1 in the NF area in either season, indicating that the increases at the MF stations may not be solely related to effluent. Similar to the variables that also triggered Action Level 1 in the NF, most of these variables only exceeded the criterion at MF3-3 (boron, cobalt, iron, lead, thallium, and tin). Concentrations of these six variables at MF3-3 were greater than those reported in the NF area, indicating that these elevated values may be related to dust deposition. However, this interpretation is not supported by similar increases at the other stations within the ZOI. Furthermore, MF3-3 is the station within the ZOI that is farthest from the Mine footprint boundary (and thus, dust sources) and, therefore, would be least likely to show effects from dust deposition.

Zinc exceeded the criterion at MF1-1. The median concentration of zinc at MF1-1 was greater than the median reported in the NF area, indicating that the elevated values within the ZOI do not appear to be solely related to dispersion of effluent in the lake and, therefore, may possibly be related to dust deposition.

Overall, analysis of the 2020 AEMP water quality data indicate that effluent is the main source of Mine effects on Lac de Gras, with a negligible contribution from dust deposition. Although some variables had greater concentrations at one or two MF area stations within the ZOI compared to the NF median, similar increases at the other stations within the ZOI were not observed. Spatial trends in variables triggering Action Level 1 showed clear gradients related to the Mine discharge within the ZOI from dust deposition. A step change (i.e., decline) in concentration was not apparent outside the ZOI for any of the evaluated variables. These results suggest that dust deposition is unlikely to be an important source of effects on water quality of Lac de Gras. This interpretation is consistent with a limited potential for effects on lake water quality demonstrated by the *Dust Special Effects Study (SES)* included in the *2019 AEMP Annual Report* (Golder 2020c).

Although dust deposition has the potential to contribute to effects on water quality during certain times of the year (e.g., ice break-up, extreme wind events), several lines of evidence suggest that isolating the specific effects from dust emissions on water quality in Lac de Gras from other mine sources (e.g., effluent) is not possible or necessary to manage Mine-related effects in Lac de Gras:

- Analyses completed in the *2017 to 2019 Aquatic Effects Re-evaluation Report* (Golder 2020b), showed spatial confounding of dust and effluent effects; this does not allow a reliable evaluation of relative effects from the two sources based on spatial trends.
- There is a lack of a dust signature in lake water chemistry. The geochemical signature of lake water (represented by water quality samples collected as part of the SES and AEMP) was similar to that of effluent, and the influence of dust could not be differentiated from that of effluent (Golder 2020c).
- There was no indication that the SES stations, which were located closer to dust sources than AEMP stations, were impacted by dust deposition on top of the effect of the Mine effluent in the 2019 *Dust SES* (Golder 2020c).
- There have been several years of not being able to isolate effects of dust from effluent-related effects. The dust deposition analysis has been included in the AEMP annual reports since 2016 and no conclusive dust effects have been shown.
- The AEMP monitors Mine-related effects in Lac de Gras from all Mine-related sources.

Therefore, it is recommended that the analysis used to evaluate potential effects from dust emissions water quality in Lac de Gras be discontinued in future AEMP reports. The AEMP sampling design provides sufficient and appropriate data to evaluate the combined effects in Lac de Gras from all Mine-related sources, including dustfall.

Table 3-13 Evaluation of Effects from Dust Deposition and Dike Construction in Lac de Gras, 2020

Variable	Unit	2020 Detection Limit	Screening Value	2020 AEMP Result (Open-water)						Median of MF Station >2× Median of Reference Dataset(a) (Yes/No)
			2× Median of Reference Areas(a)	Median of NF Values	Highest NF Station Median Value	Median of MF Values(b)				
						MF1-1	MF3-1	MF3-2	MF3-3	
Conventional Parameters										
Total alkalinity	mg/L	0.5	8	5.59	5.85	5.15	4.51	4.83	4.36	No
Total dissolved solids, calculated	mg/L	-	10.0	21	21.6	**18.1**	**15.6**	**14.7**	**18.8**	**Yes(c)**
Total dissolved solids, measured	mg/L	1	20	26.4	27.2	**22**	**22**	17.6	18.8	**(d)**
Total suspended solids	mg/L	1	1	1.3	1.5	**1.5**	**1.4**	**1.5**	<1	**Yes(c)**
Total organic carbon	mg/L	0.2	4.4	2.5	2.6	2.4	2.1	2.4	2.1	No
Turbidity – lab	NTU	0.1	0.42	0.23	0.37	0.25	0.17	<0.1	<0.1	No
Major Ions										
Calcium (dissolved)	mg/L	0.01	2.0	2.1	2.2	2.0	1.7	1.6	**2.9**	**Yes(c)**
Chloride	mg/L	0.5	2.0	4.4	4.7	**4.0**	**3.3**	**2.7**	**3.0**	**Yes(c)**
Fluoride	mg/L	0.01	0.044	0.029	0.030	0.027	0.027	0.028	0.027	No
Magnesium (dissolved)	mg/L	0.005	1.4	1.2	1.3	1.1	1.0	0.96	**1.6**	**Yes(c)**
Potassium (dissolved)	mg/L	0.01	1.2	1.2	1.3	1.0	0.88	0.84	**1.4**	**Yes(c)**
Sodium (dissolved)	mg/L	0.01	1.0	3.2	3.3	**2.6**	**2.2**	**1.9**	**3.2**	**Yes(c)**
Sulphate	mg/L	0.5	3.8	5.1	5.3	**4.5**	3.8	**3.9**	**4.0**	**Yes(c)**
Nutrients										
Ammonia(e)	µg-N/L	5	5	6.9	90	<5	**41**	**12**	**43**	**Yes(c)**
Nitrate	µg-N/L	2	2	44	47	**32**	**9.8**	**3.8**	<2	**Yes(c)**
Nitrite	µg-N/L	1	2	<1	3.1	<1	<1	<1	<1	No
Total Metals										
Aluminum	µg/L	0.2	8.8	6.2	7.02	5.75	4.9	3.87	**11**	**Yes(c)**
Antimony	µg/L	0.02	0.02	0.023	0.026	**0.021**	<0.02	<0.02	<0.02	**Yes(c)**
Arsenic	µg/L	0.02	0.34	0.26	0.28	0.27	0.27	0.22	0.32	No
Barium	µg/L	0.02	3.62	3.13	3.28	2.7	2.35	2.09	3.36	No
Beryllium	µg/L	0.01	0.01	<0.01	0.005	<0.01	<0.01	<0.01	<0.01	No
Bismuth	µg/L	0.005	0.005	<0.005	0.0025	<0.005	<0.005	<0.005	<0.005	No
Boron	µg/L	5	5	<5	<5	<5	<5	<5	**7.8**	**Yes**
Cadmium	µg/L	0.005	0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	No
Calcium	mg/L	0.01	1.92	2.04	2.2	1.89	1.69	1.55	**2.55**	**(d)**
Chromium	µg/L	0.05	0.06	<0.05	0.063	0.057	<0.05	<0.05	0.055	No
Cobalt	µg/L	0.005	0.04	0.017	0.022	0.018	0.024	0.016	**0.062**	**Yes**
Copper	µg/L	0.05	0.6	0.56	0.58	0.57	0.55	0.54	**0.88**	**Yes(c)**
Iron	µg/L	1	10	4.5	5.2	4.9	4.9	4.3	**20**	**Yes**

Table 3-13 Evaluation of Effects from Dust Deposition and Dike Construction in Lac de Gras, 2020 (continued)

Variable	Unit	2020 Detection Limit	Screening Value	2020 AEMP Result (Open-water)						Median of MF Station >2× Median of Reference Dataset(a) (Yes/No)
			2× Median of Reference Areas(a)	Median of NF Values	Highest NF Station Median Value	Median of MF Values(b)				
						MF1-1	MF3-1	MF3-2	MF3-3	
Lead	µg/L	0.005	0.005	<0.005	<0.005	<0.005	<0.005	<0.005	**0.0058**	**Yes**
Lithium	µg/L	0.5	2.4	1.59	1.72	1.5	1.45	1.2	2.24	No
Magnesium	mg/L	0.005	1.26	1.16	1.23	1.09	1.01	0.954	**1.45**	(d)
Manganese	µg/L	0.05	4.88	1.8	2.02	1.83	1.69	1.4	4	No
Mercury	µg/L	0.002	0.01	<0.0019	<0.0019	<0.002	<0.002	<0.002	<0.002	No
Molybdenum	µg/L	0.05	0.18	0.92	1.1	**0.73**	**0.44**	**0.30**	**0.43**	**Yes(c)**
Nickel	µg/L	0.02	1.9	0.70	0.75	0.70	0.87	0.90	1.5	No
Potassium	mg/L	0.01	1.08	1.13	1.26	1.01	0.889	0.818	**1.27**	(d)
Selenium	µg/L	0.04	0.04	<0.04	<0.04	<0.04	<0.04	<0.04	<0.04	No
Silicon	µg/L	50	50	71	79	**51**	<50	<50	**58**	**Yes(c)**
Silver	µg/L	0.005	0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	No
Sodium	mg/L	0.01	1.26	2.93	3.3	**2.58**	**2.19**	**1.88**	**2.83**	(d)
Strontium	µg/L	0.05	14.6	27.7	30.8	**25**	**19.7**	**16.8**	**23.9**	**Yes(c)**
Sulphur	mg/L	0.5	1.82	1.7	1.98	1.61	1.41	1.18	**1.9**	**Yes(c)**
Thallium	µg/L	0.002	0.002	<0.002	0.0021	<0.002	<0.002	<0.002	**0.0026**	**Yes**
Tin	µg/L	0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	**0.037**	**Yes**
Titanium	µg/L	0.5	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	No
Uranium	µg/L	0.002	0.056	0.137	0.153	**0.11**	**0.070**	**0.059**	**0.097**	**Yes(c)**
Vanadium	µg/L	0.05	0.1	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	No
Zinc	µg/L	0.1	1.5	0.89	1.69	**1.72**	0.6	0.64	<0.1	**Yes**
Zirconium	µg/L	0.05	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	No

a) The 2× the median value was based on the reference area median concentrations presented in the *AEMP Reference Conditions Report Version 1.4* (Golder 2019a). In cases where the median concentration was less than the DL, the reference area median value was considered to be equal to half of the DL.

b) The median of MF area values was calculated from data pooled across all sample depths (i.e., top, middle, and bottom).

c) Concentration in the NF area triggered both Action Level 1 (during one or both seasons) and an effect equivalent to Action Level 1 at one or more MF area stations located within the estimated zone of influence from dust deposition.

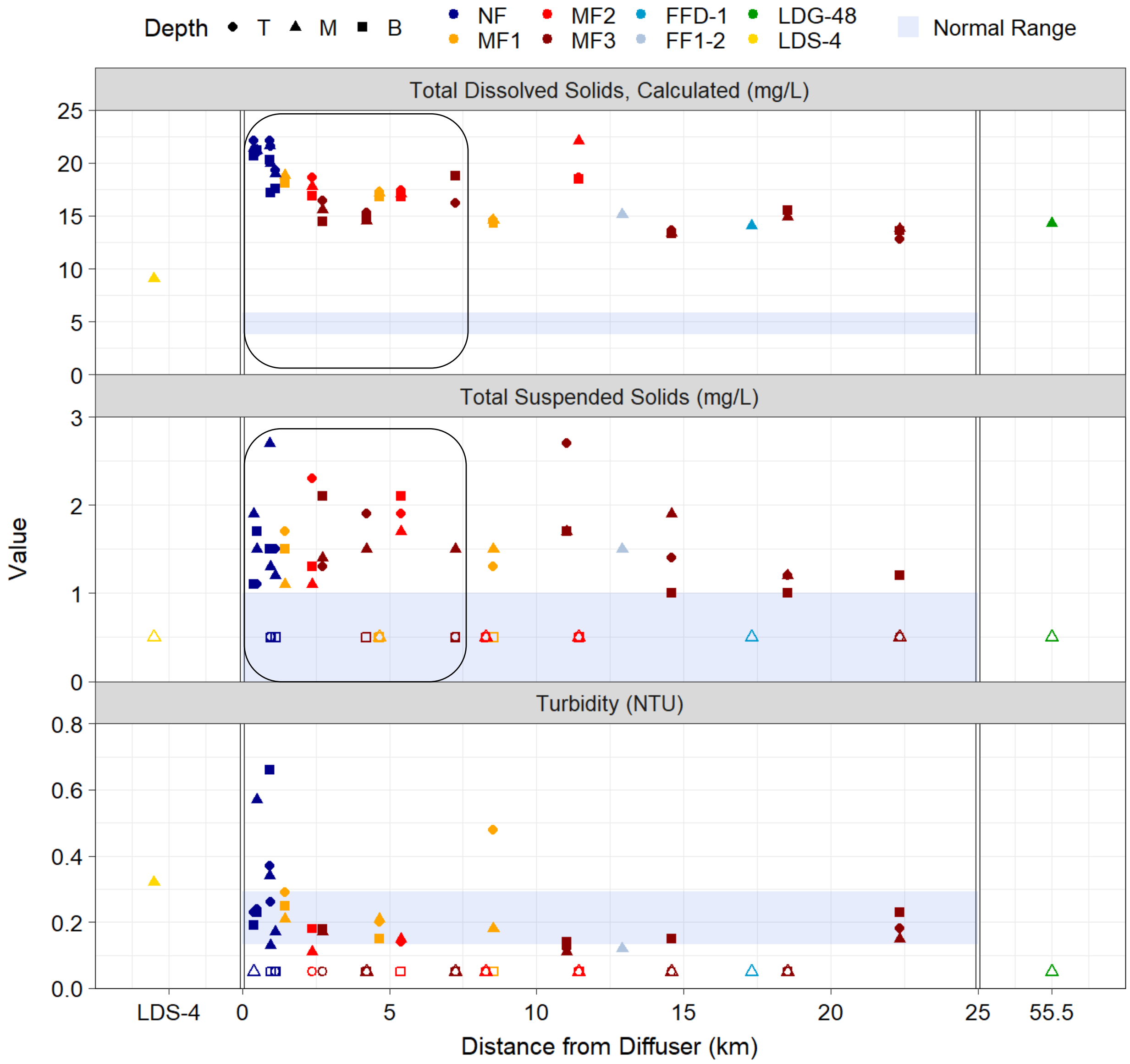
d) “Yes” applied to dissolved or calculated value to avoid duplication.

e) Based on the results of the ammonia investigation, the ALS ammonia dataset was used in both seasons (Section 2.3.1, Attachment B).

Note: **Bolding** and shading indicate that a MF median value exceeded two times the reference dataset median.

NTU = nephelometric turbidity unit; µg-N/L = micrograms nitrogen per litre; >= greater than; < = less than; 2 x = two times; NF = near-field; MF = mid-field.

Figure 3-54 **Spatial Variation in Total Dissolved Solids, Calculated, Total Suspended Solids, and Turbidity According to Distance from the Effluent Discharge, Open-water Season, 2020**

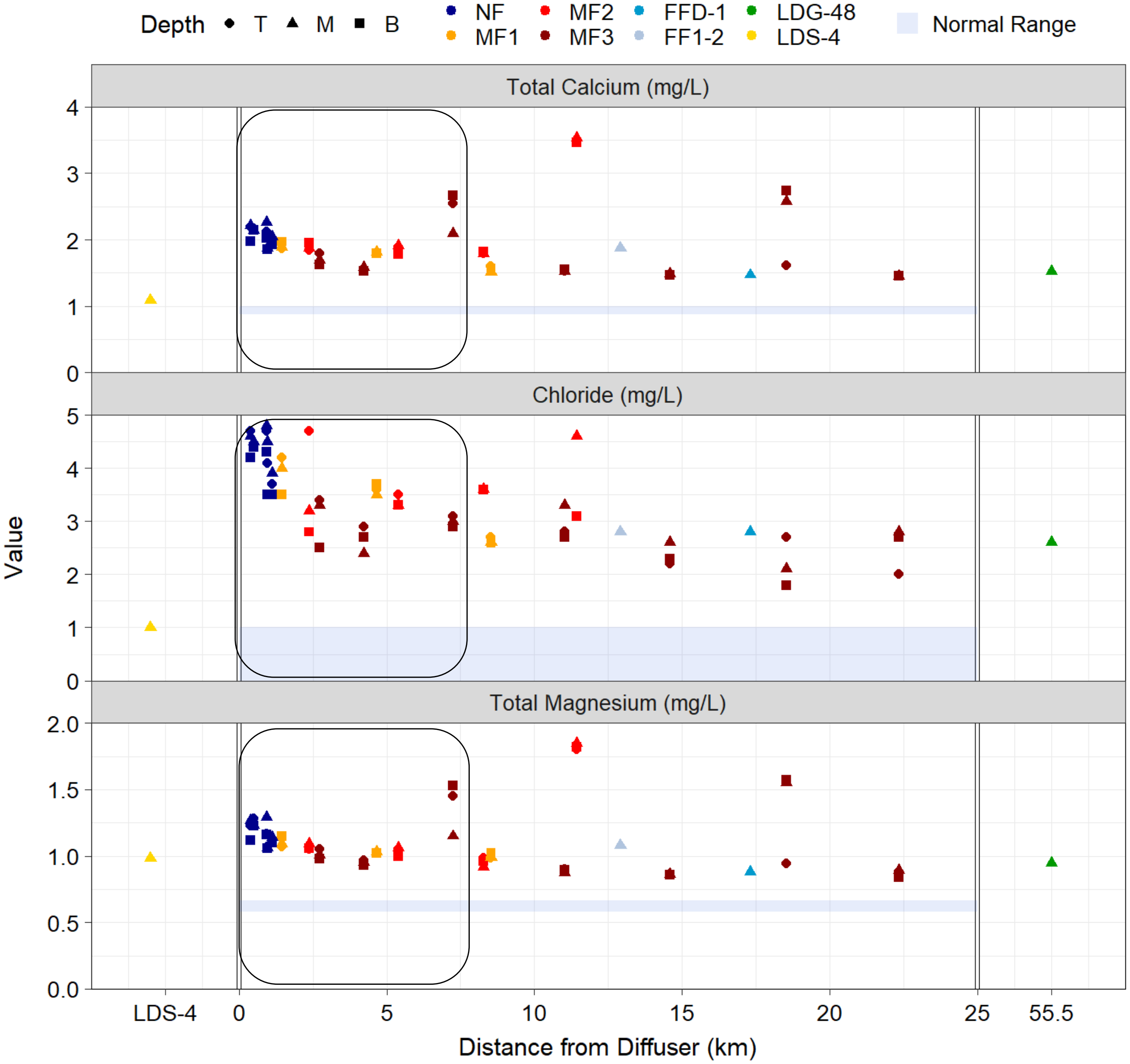


Notes: Values represent concentrations in individual samples collected at top, middle and bottom depths. Open symbols represent non-detect data.

T = top depth; M = middle depth; B = bottom depth; NF = near-field; MF = mid-field; FF = far-field; NTU = nephelometric turbidity unit; LDG = Lac de Gras; LDS = Lac du Sauvage.

▭ Solid line ellipse indicates stations that fall within the ZOI from dust deposition and is shown for variables that met Criterion 4 in the SOI selection process (Section 2.4.1)

Figure 3-55 Spatial Variation in Calcium (Total), Chloride, and Magnesium (Total) Concentrations According to Distance from the Effluent Discharge, Open-water Season, 2020

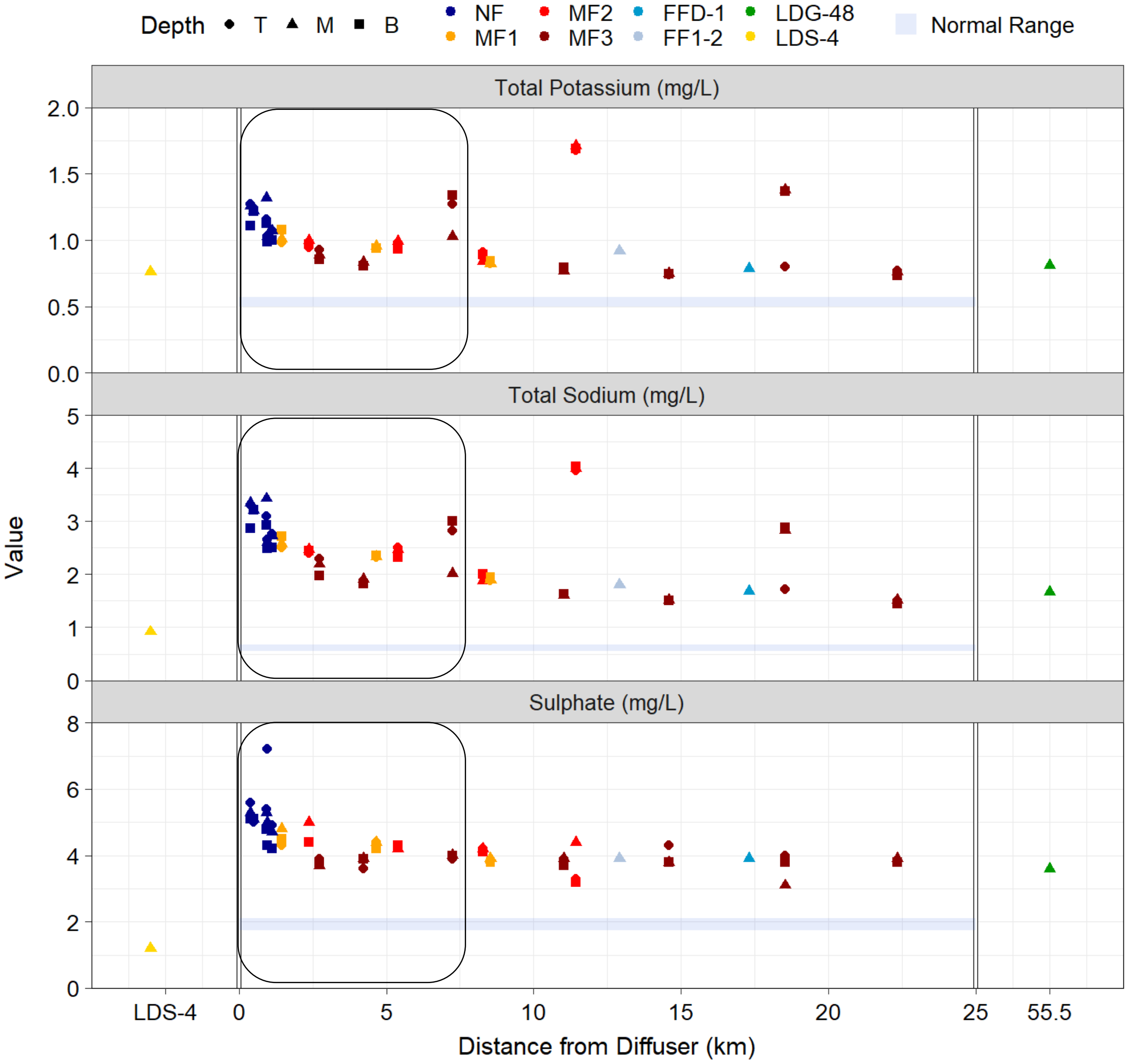


Notes: Values represent concentrations in individual samples collected at top, middle and bottom depths. Open symbols represent non-detect data.

T = top depth; M = middle depth; B = bottom depth; NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage.

▢ Solid line ellipse indicates stations that fall within the ZOI from dust deposition and is shown for variables that met Criterion 4 in the SOI selection process (Section 2.4.1)

Figure 3-56 **Spatial Variation in Potassium (Total), Sodium (Total), and Sulphate Concentrations According to Distance from the Effluent Discharge, Open-water Season, 2020**

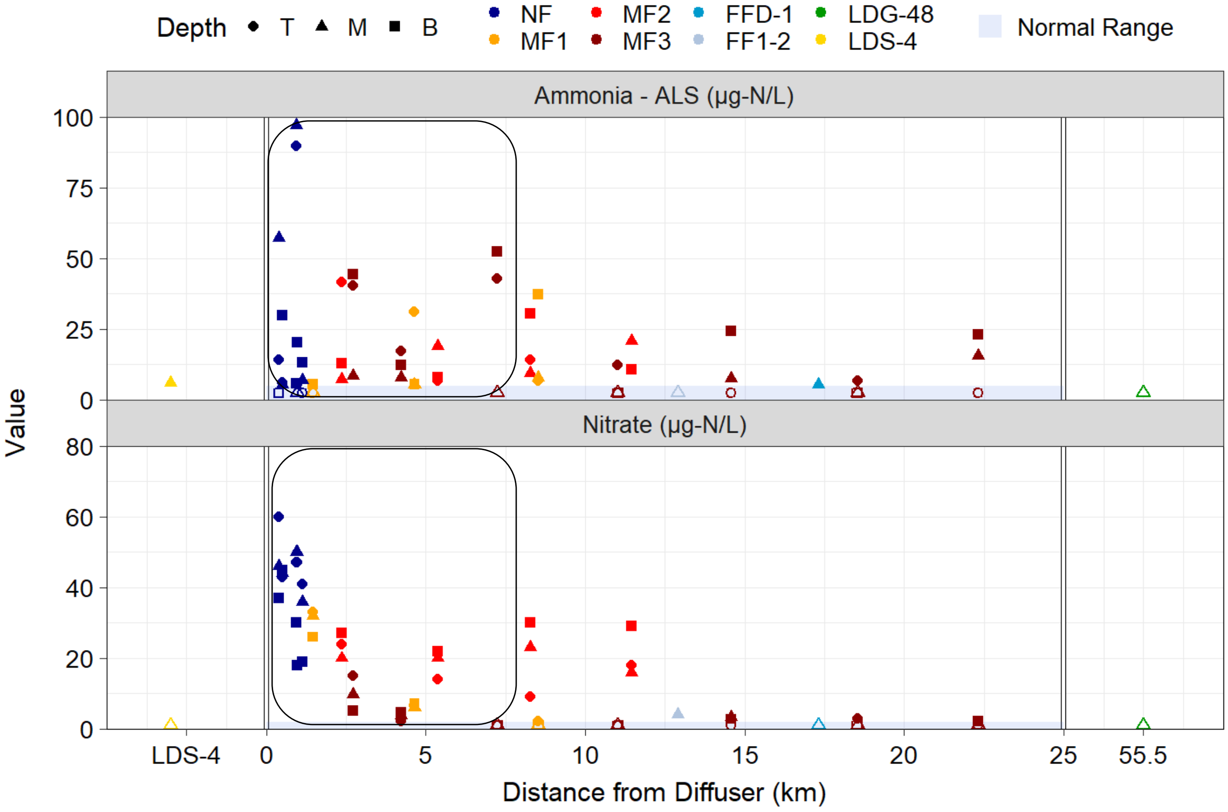


Notes: Values represent concentrations in individual samples collected at top, middle and bottom depths. Open symbols represent non-detect data.

T = top depth; M = middle depth; B = bottom depth; NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage.

▢ Solid line ellipse indicates stations that fall within the ZOI from dust deposition and is shown for variables that met Criterion 4 in the SOI selection process (Section 2.4.1)

Figure 3-57 Spatial Variation in Ammonia and Nitrate Concentrations According to Distance from the Effluent Discharge, Open-water Season, 2020

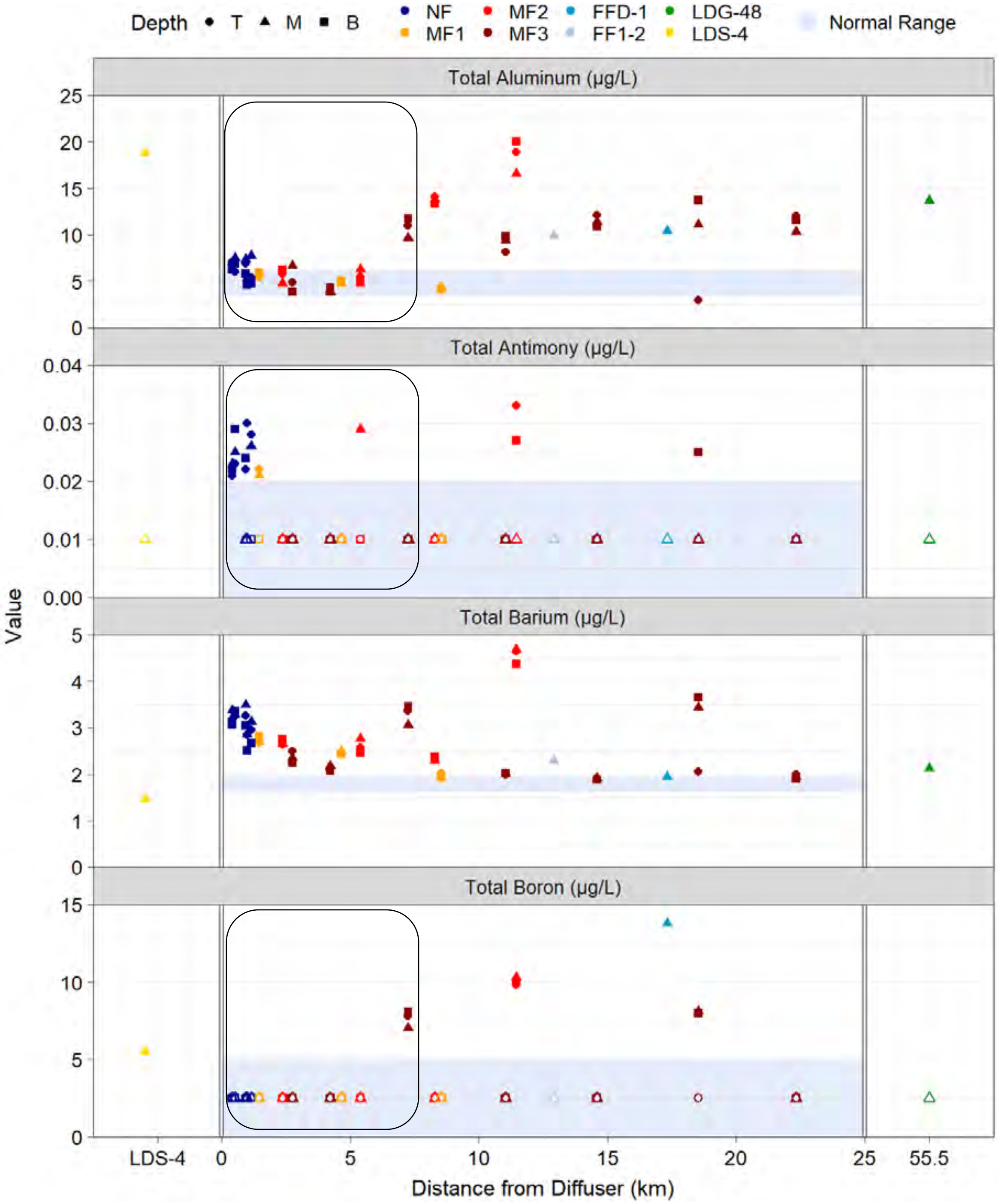


Notes: Values represent concentrations in individual samples collected at top, middle and bottom depths. Open symbols represent non-detect data.

T = top depth; M = middle depth; B = bottom depth NF = near-field; MF = mid-field; FF = far-field; µg-N/L = micrograms nitrogen per litre; LDG = Lac de Gras; LDS = Lac du Sauvage.

▢ Solid line ellipse indicates stations that fall within the ZOI from dust deposition and is shown for variables that met Criterion 4 in the SOI selection process (Section 2.4.1)

Figure 3-58 **Spatial Variation in Aluminum, Antimony, Barium, and Boron Concentrations According to Distance from the Effluent Discharge, Open-water Season, 2020**

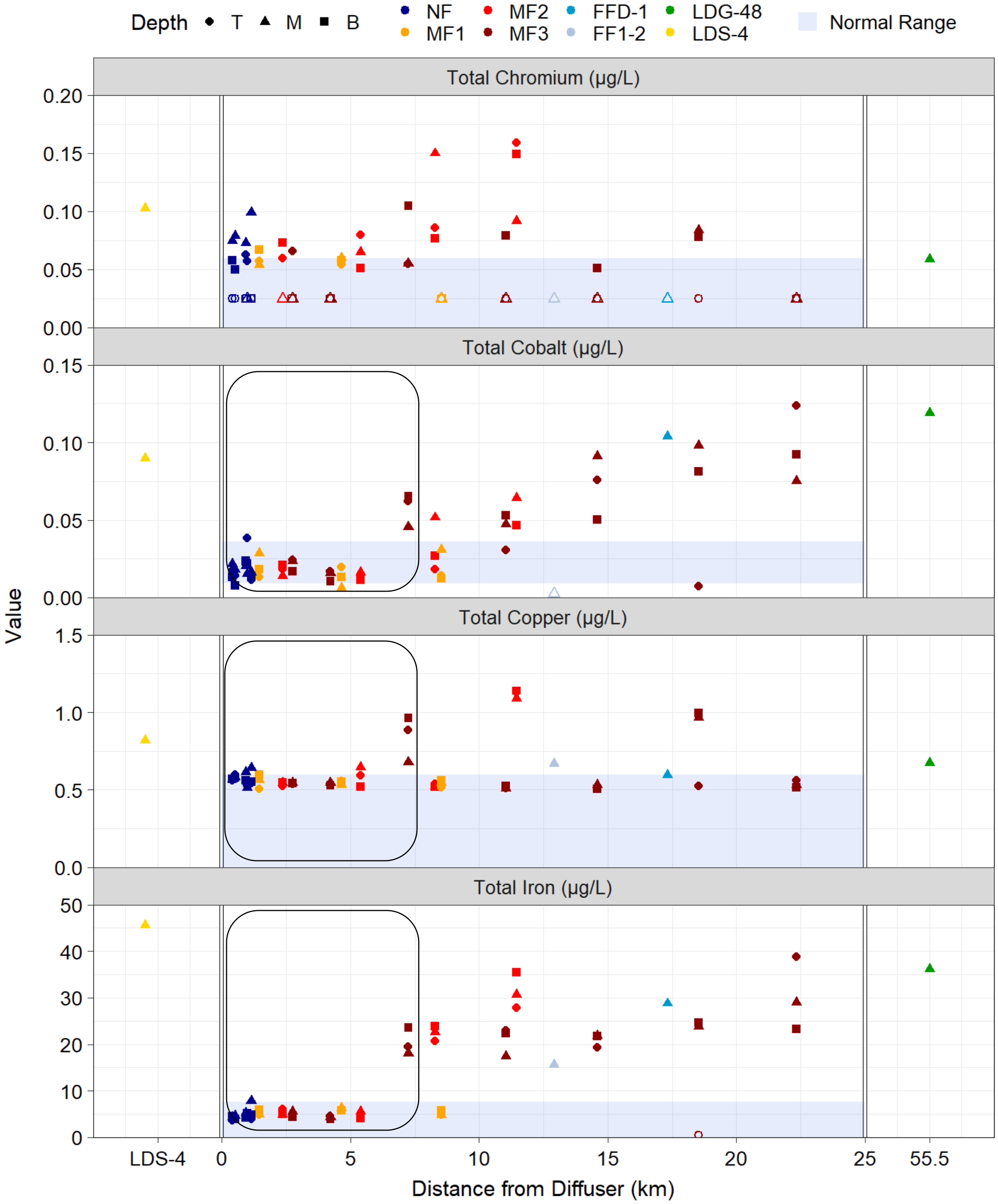


Notes: Values represent concentrations in individual samples collected at the top, middle and bottom depths. Open symbols represent non-detect data.

T = top depth; M = middle depth; B = bottom depth; NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage.

▢ Solid line ellipse indicates stations that fall within the ZOI from dust deposition and is shown for variables that met Criterion 4 in the SOI selection process (Section 2.4.1)

Figure 3-59 Spatial Variation in Chromium, Cobalt, Copper, and Iron Concentrations According to Distance from the Effluent Discharge, Open-water Season, 2020

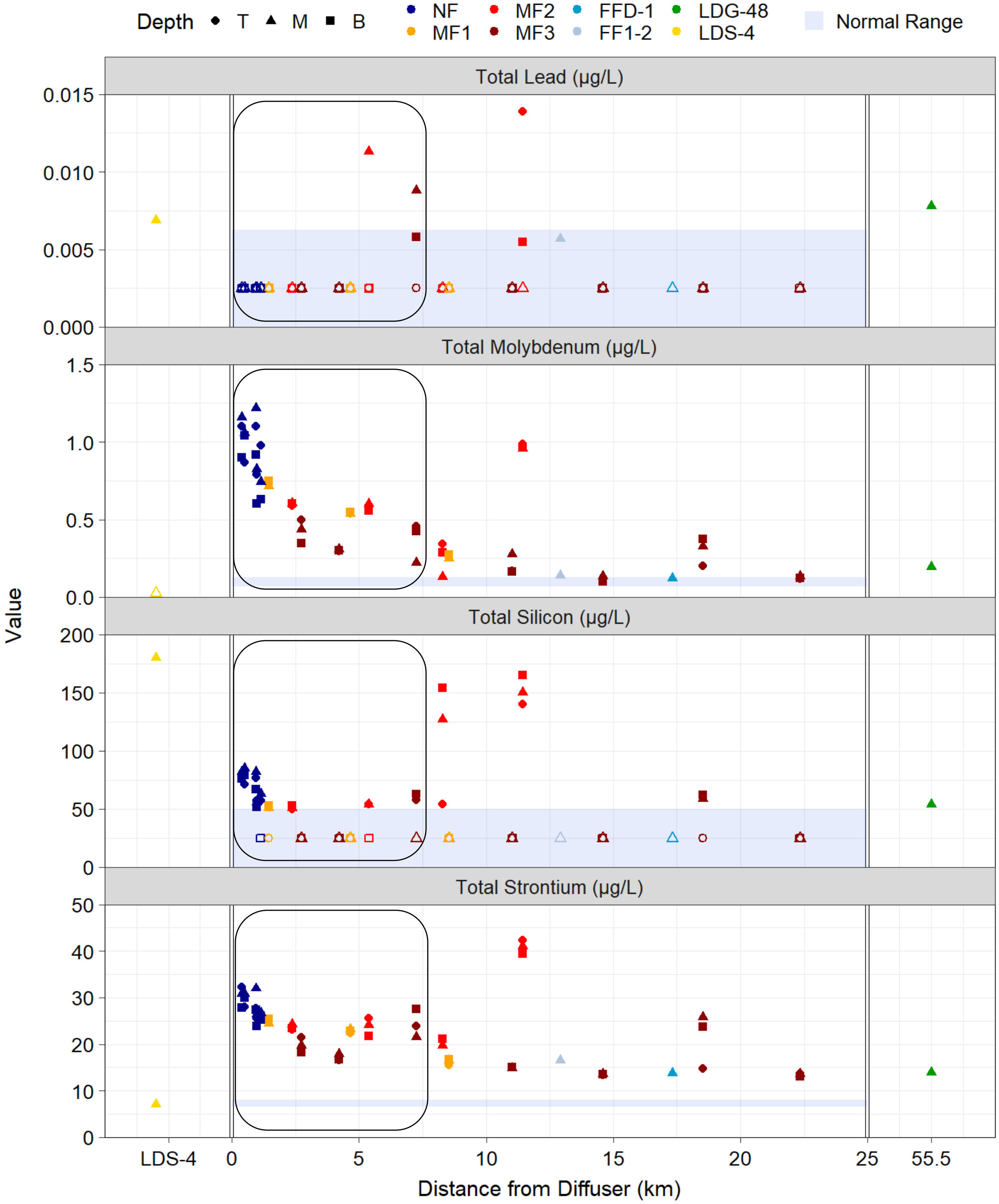


Notes: Values represent concentrations in individual samples collected at the top, middle and bottom depths. Open symbols represent non-detect data.

T = top depth; M = middle depth; B = bottom depth; NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage.

▢ Solid line ellipse indicates stations that fall within the ZOI from dust deposition and is shown for variables that met Criterion 4 in the SOI selection process (Section 2.4.1)

Figure 3-60 Spatial Variation in Lead, Molybdenum, Silicon, and Strontium Concentrations According to Distance from the Effluent Discharge, Open-water Season, 2020

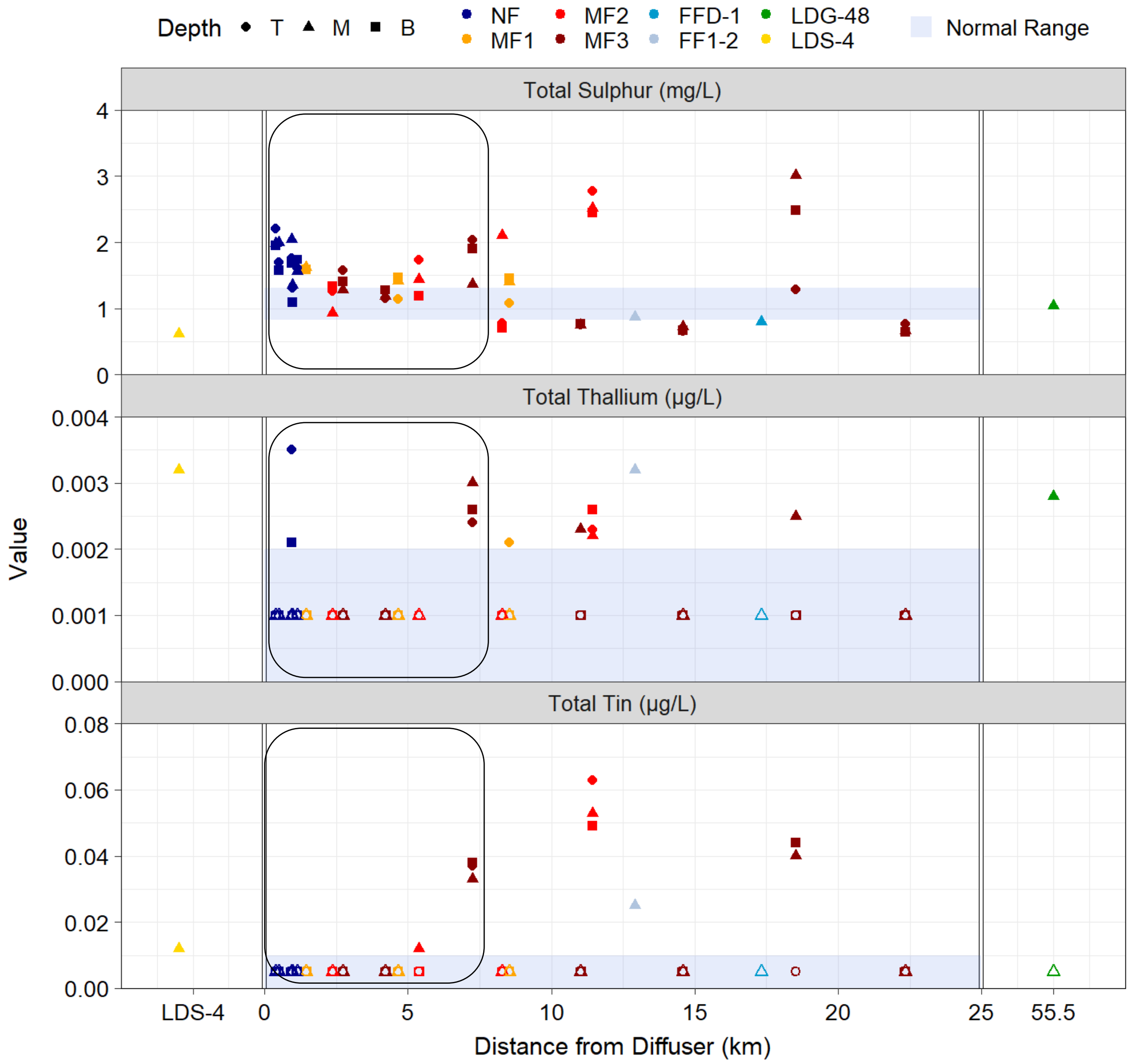


Notes: Values represent concentrations in individual samples collected at the top, middle and bottom depths. Open symbols represent non-detect data.

T = top depth; M = middle depth; B = bottom depth; NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage.

☐ Solid line ellipse indicates stations that fall within the ZOI from dust deposition and is shown for variables that met Criterion 4 in the SOI selection process (Section 2.4.1)

Figure 3-61 Spatial Variation in Sulphur, Thallium, and Tin Concentrations According to Distance from the Effluent Discharge, Open-water Season, 2020

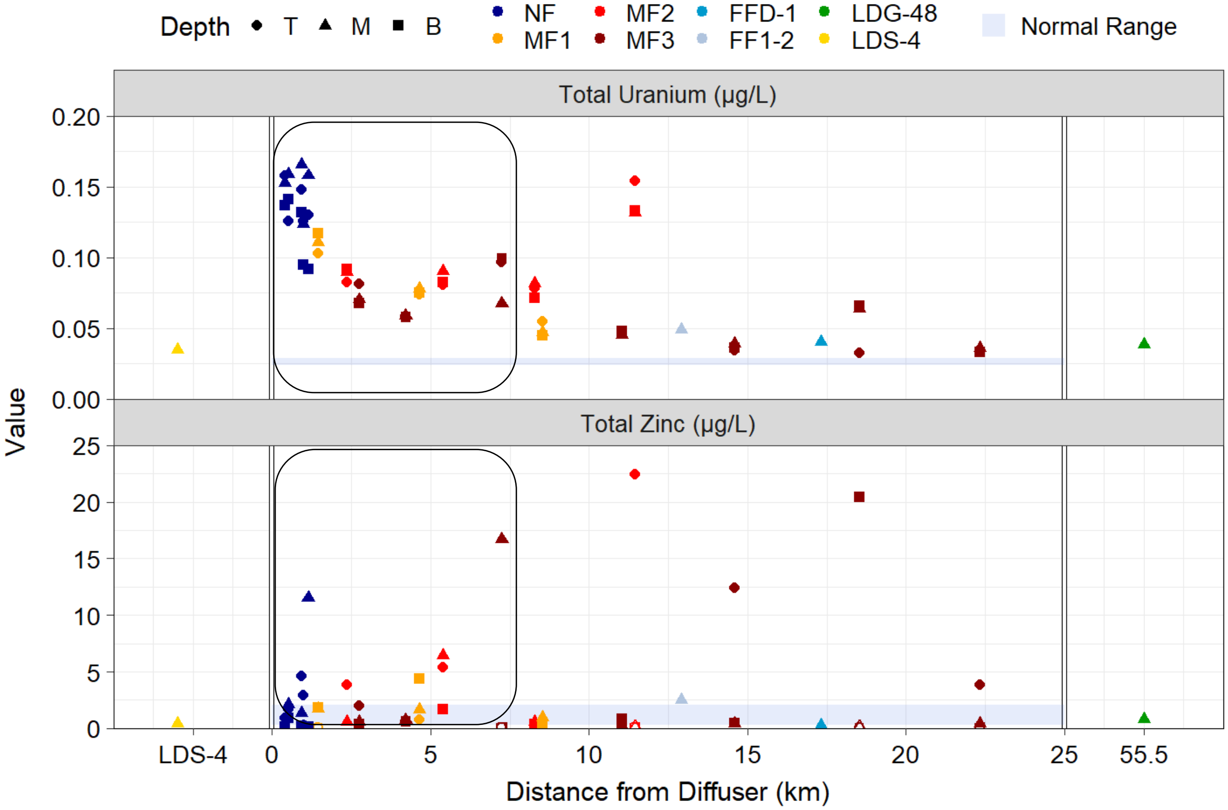


Notes: Values represent concentrations in individual samples collected at the top, middle and bottom depths. Open symbols represent non-detect data.

T = top depth; M = middle depth; B = bottom depth; NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage.

▢ Solid line ellipse indicates stations that fall within the ZOI from dust deposition and is shown for variables that met Criterion 4 in the SOI selection process (Section 2.4.1)

Figure 3-62 Spatial Variation in Uranium and Zinc Concentrations According to Distance from the Effluent Discharge, Open-water Season, 2020



Notes: Values represent concentrations in individual samples collected at the top, middle and bottom depths. Open symbols represent non-detect data.

T = top depth; M = middle depth; B = bottom depth; NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage.

▢ Solid line ellipse indicates stations that fall within the ZOI from dust deposition and is shown for variables that met Criterion 4 in the SOI selection process (Section 2.4.1)

4 SUMMARY AND DISCUSSION

Concentrations of variables with EQC were within applicable limits in samples collected in 2020 and no variables were added to the SOI list based on effluent screening (Criterion 1 in Table 3-1). Toxicity testing results in 2020 indicated that effluent samples were generally not toxic to aquatic test organisms. None of the mixing zone chemistry variables with Effects Benchmarks were added to the SOI list because concentrations in all samples analyzed during the 2020 reporting period were below the relevant Effects Benchmarks (Criterion 2 in Table 3-1).

Water quality variables measured in Lac de Gras as part of the 2020 AEMP were assessed for a Mine-related effect according to Action Levels. Twenty-one variables triggered Action Level 1, which is an early-warning indicator of effects in Lac de Gras. These 21 variables were retained as SOIs in 2020 (Criterion 3 in Table 3-1). The SOI variables had NF area median concentrations that were greater than two times the median concentrations in the reference condition dataset. Each of the SOIs that triggered Action Level 1 was detected in the NIWTP effluent at a higher concentration than in lake water or was identified in dust associated with the Mine, indicating that the increase observed in the NF area could be linked to the Mine. Of the 21 variables that triggered Action Level 1 and were retained as SOIs, eight also triggered Action Level 2. None of the SOIs triggered Action Level 3 in 2020.

Spatial trends of decreasing concentrations with distance from the Mine effluent discharge were evident for most of the 21 SOIs that triggered Action Level 1 or 2 in 2020, based on a graphical and statistical evaluation of the data. An exception was TSS, which had concentrations in the MF area similar to those measured in the NF area in both seasons. The results of these analyses provided confirmation that the changes for these variables observed in the NF area were related to the Mine effluent discharge.

In 2020, an additional seven variables (i.e., boron, cobalt, iron, lead, thallium, tin, and zinc) were included in the list of SOIs in 2020, as concentrations of these variables were greater than two times the median of the reference dataset value at stations in the MF area within the estimated ZOI from dust deposition from the Mine, but not in the NF area. These variables had median concentrations at one or more of the four MF stations that were elevated compared to the median of the NF area concentrations. While there is some potential that these elevated values may be related to dust deposition, this interpretation is not supported by similar increases at the other stations within the ZOI and spatial trends within the ZOI were consistent with effects originating from the Mine effluent. Overall, analysis of the 2020 AEMP water quality data indicate that effluent is the main source of Mine effects on Lac de Gras, with a negligible contribution from dust deposition, consistent with previous years’ assessments.

5 RESPONSE FRAMEWORK

Water quality variables were assessed for a Mine-related effect according to Action Levels in the Response Framework. Twenty-one variables triggered Action Level 1 (i.e., TDS [calculated], TSS, turbidity, calcium, chloride, magnesium, potassium, sodium, sulphate, ammonia, nitrate, aluminum, antimony, barium, chromium, copper, molybdenum, silicon, strontium, sulphur, and uranium). No management action is required under the Response Framework when a variable triggers Action Level 1. Of the 21 variables that triggered Action Level 1, eight also triggered Action Level 2 (i.e., TDS [calculated], chloride, sodium, sulphate, nitrate, molybdenum, strontium, and uranium). The required management action when a water quality variable triggers Action Level 2 is to establish an AEMP Effects Benchmark for that variable if one does not already exist. All eight variables that triggered Action Level 2 have existing Effects Benchmarks; therefore, no action was required. No water quality variables triggered Action Level 3 in 2020.

6 CONCLUSIONS

Based on the analysis of water quality data collected during the 2020 AEMP program, the following conclusions can be drawn:

- The 2020 effluent toxicity results indicated that the effluent discharged to Lac de Gras in 2020 was non-toxic; all effluent samples submitted for lethal and sublethal toxicity testing passed test criteria.
- The concentrations of all regulated effluent variables were below applicable EQC values.
- Nearly all concentrations (>99%) measured in samples collected at the mixing zone boundary were within the relevant AEMP water quality Effects Benchmarks for the protection of aquatic life and drinking water.
- In the ice-cover season, elevated conductivity was measured in the bottom two-thirds of the water column in the NF area, indicating the depth range where the effluent plume was located. During the open-water season, in situ water quality measurements were typically uniform throughout the water column.
- Concentrations of nearly all variables in samples collected during the 2020 AEMP were below the relevant Effects Benchmarks for the protection of aquatic life and drinking water. In most cases, identified exceedances appeared to be caused by contamination or data errors or were attributable to natural conditions in Lac de Gras.
- In 2020, 21 water quality variables demonstrated an effect equivalent to Action Level 1 (i.e., TDS [calculated], TSS, turbidity, calcium, chloride, magnesium, potassium, sodium, sulphate, ammonia, nitrate, aluminum, antimony, barium, chromium, copper, molybdenum, silicon, strontium, sulphur, and uranium), and were included in the list of SOIs in 2020 (Table 6-1).
- Of the 21 SOIs that triggered Action Level 1, eight also triggered Action Level 2 (i.e., TDS [calculated], chloride, sodium, sulphate, nitrate, molybdenum, strontium, and uranium; Table 6-1); these eight variables already have existing Effects Benchmarks.
- None of the SOIs triggered Action Level 3 (Table 6-1).
- Spatial trends of decreasing concentrations with distance from the Mine effluent discharge were evident for most SOIs based on a graphical and statistical evaluation of the data. An exception was TSS, which had concentrations in the MF area similar to those measured in the NF area in both seasons.
- Twenty-five variables triggered an effect equivalent to Action Level 1 at one or more of the four MF area stations located within the estimated ZOI from dust deposition from the Mine site. Of these 25 SOIs, 18 also triggered Action Level 1 in the NF area, indicating that the exceedances at the MF stations were at least partly caused by dispersion of Mine effluent into the lake. Analysis of the 2020 AEMP water quality data did not provide evidence to suggest an effect of dust deposition from the Mine site on the water quality of Lac de Gras.

Table 6-1 Action Level Summary for Water Quality Substances of Interest, 2020

2020 SOIs	Action Level Classification
Conventional Parameters	
Total dissolved solids, calculated	2
Total suspended solids	1
Turbidity – lab	1
Major Ions	
Calcium (dissolved)	1
Chloride	2
Magnesium (dissolved)	1
Potassium (dissolved)	1
Sodium (dissolved)	2
Sulphate	2
Nutrients	
Ammonia	1
Nitrate	2
Total Metals	
Aluminum	1
Antimony	1
Barium	1
Boron	0(a)
Chromium	1
Cobalt	0(a)
Copper	1
Iron	0(a)
Lead	0(a)
Molybdenum	2
Silicon	1
Strontium	2
Sulphur	1
Thallium	0(a)
Tin	0(a)
Uranium	2
Zinc	0(a)

a) Variable added to the list of SOIs because it triggered an effect equivalent to Action Level 1 at one or more MF stations located within the estimated zone of influence from dust deposition (see Section 3.7), but not in the NF area.

0 = Action Level not triggered; 1 = Action Level 1 triggered; 2 = Action Level 2 triggered.

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8 CLOSURE

We trust the information in this report meets your requirements at this time. If you have any questions relating to the information contained in this report, please do not hesitate to contact the undersigned.

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ATTACHMENT A

2020 AEMP SAMPLING SCHEDULE

Table A-1 2020 AEMP Sampling Schedule

Sites	Ice-cover										Open-water									
	April									May	August									September
	20	21	22	23	25	26	27	28	29	1	16	18	19	21	22	27	28	29	31	7
NF1								An												Anp
NF2		An																		Anp
NF3	An(a)																			Anp
NF4								An										Anp(a)		
NF5										An								Anp		
MF1-1		An(a)																	Anp(a)	
MF1-3		An																	Anp	
MF1-5			An(a)																Anp	
MF2-1							An										Anp			
MF2-3										An							Anp			
FF2-2									An				Anp(a)							
FF2-5									An(a)				Anp							
MF3-1							An(a)										Anp			
MF3-2							An									Anp				
MF3-3					An										Anp					
MF3-4						An									Anp					
MF3-5						An								Anp						
MF3-6						An								Anp						
MF3-7				An										Anp						
FF1-2			Mn									Mnp(a)								
FFD-1				Mn(a)								Mnp								
LDG-48					Mn						Mnp(b)									
LDS-4											Mnp(b)									

Notes:

A = water quality sampled collected from surface, middle depth and bottom depth; M = mid-depth sample collected; n = nutrient sample collected; p = plankton sample collected; QA/QC = quality assurance/quality control.

a) Quality control samples were collected for total ammonia only.

b) Only chlorophyll a was sampled, not plankton.

Note: QA/QC samples are colour coded: Grab Water (GW), Equipment Blank (EBW), Field Blank (FBW), Trip Blank (TBW), and Duplicate 1/Duplicate 2 (DUP1/DUP2).

NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage.

ATTACHMENT B

QUALITY ASSURANCE AND QUALITY CONTROL METHODS AND RESULTS

QUALITY ASSURANCE AND QUALITY CONTROL METHODS AND RESULTS

Introduction

Quality assurance and quality control (QA/QC) practices determine data integrity and are relevant to all aspects of a study, from sample collection to data analysis and reporting. Quality assurance encompasses management and technical practices designed to generate consistent, high quality data. Quality control is an aspect of quality assurance and includes the techniques used to assess data quality and the corrective actions to be taken when the data quality objectives are not met. Details of the QA/QC practices applied during the Aquatic Effects Monitoring Program (AEMP) are described in the *Quality Assurance Project Plan (QAPP) Version 3.1* (Golder 2017). This appendix describes QA/QC practices applied during the 2020 AEMP, evaluates quality control data, and describes the implications of QC results to the interpretation of study results.

Quality Assurance

Field Staff Training and Operations

Diavik Diamond Mines (2012) Inc. (DDMI) field staff are trained to be proficient in standardized field sampling procedures, data recording, and equipment operations applicable to water quality sampling. Field work was completed according to specified instructions and standard operating procedures (SOP) as follows:

- ENVI-923-0119 “AEMP SOP Combined Open Water and Ice Cover”
- ENVI-915-0119 “SOP SNP Sampling”
- ENVI-902-0119 “SOP Quality Assurance Quality Control”
- ENVI-900-0119 “SOP Chain of Custody”
- ENVI-905-0119 "SOP pH Analysis”
- ENVI-906-0119 "SOP Turbidity Analysis”
- ENVI-904-0119 “SOP Total Suspended Solids”
- ENVI-918-0119 “SOP Field Meter”
- ENVI-684-0317 “SOP YSI ProDSS”

These SOPs include guidelines for field record-keeping and sample tracking, guidance for use and calibration of sampling equipment, relevant technical procedures, and sample labelling, shipping and tracking protocols.

Laboratory Analyses

Samples were sent for analysis to Bureau Veritas Laboratories (BV Labs; formerly Maxxam Analytics Inc.), a laboratory accredited by the Canadian Association of Laboratory Accreditation (CALA). Duplicate samples for ammonia analysis were also sent to ALS Laboratories (ALS), another CALA accredited lab. Under the accreditation program, performance assessments are completed annually for laboratory procedures, analytical methods, and internal quality control.

Quality assurance completed by the DDMI Environmental Sampling team encompasses all quality-related activities related to aquatic testing and analysis, and relevant technical support.

DDMI's quality assurance places an emphasis on four aspects:

- infrastructure (i.e., instruments, testing capabilities, calibrations, SOPs)
- control measures (i.e., internal/external)
- personnel (i.e., competence, ethics and integrity)
- data management

Field and Office Operations

A quality assurance system was established as an organized system of data control, analysis and filing. Relevant elements of this system are as follows:

- pre-field meetings to discuss specific work instructions with field crews
- field crew check-in with task managers every 24 to 48 hours to report work completed during that period
- designating two crew members responsible for:
    - collecting all required samples
    - downloading and storing electronic data
    - completing chain-of-custody and analytical request forms; labelling and documentation
    - processing, where required, and delivering samples to the analytical laboratory in a timely manner
- cross-checking chain-of-custody forms and analysis request forms by the task manager to verify that the correct analysis packages had been requested
- review of field sheets by the task manager for completeness and accuracy
- reviewing laboratory data immediately after receipt from the analytical laboratory
- creating backup files before data analysis
- completing appropriate logic checks and verifying accuracy of calculations

Quality Control

Quality control is a specific aspect of quality assurance and includes the techniques used to assess data quality and the remedial measures to be taken when the data quality objectives are not met. The field QC program included collection of field blanks, trip blanks, equipment blanks, and duplicate samples to assess potential sample contamination, and within-station variation (i.e., sampling precision). Quality control samples were submitted to BV Labs for analysis of the full list of variables, and to ALS for analysis of ammonia.

Field blanks consisted of samples prepared in the field using laboratory-provided de-ionized water to fill a set of sample bottles, which were then submitted to the appropriate laboratory for the same analyses as the original water samples. Trip blanks consisted of sample bottles filled with high-grade de-ionized water from the laboratory. They accompanied the other samples through sample collection, handling, shipping and analysis, but remained sealed. Equipment blanks consisted of de-ionized water exposed to all aspects of sample collection and analysis, using the same procedures used in the field, including contact with all sampling devices (i.e., beta bottle) and other equipment (i.e., filters, tubing). Equipment blanks provide information regarding potential cross-contamination between samples and contamination introduced by field equipment.

The field, trip and equipment blanks were used to detect potential sample contamination during collection, shipping and analysis. Although concentrations of all variables should be below their respective detection limit (DL) in these blanks, their concentrations were considered notable if they were greater than five times the corresponding DL. This threshold is based on the Practical Quantitation Limit defined by the United States Environmental Protection Agency (US EPA 1994, 2007; BC MOE 2009), which takes into account the potential for data accuracy errors when variable concentrations approach or are below DLs.

Notable results observed in the blanks were evaluated relative to concentrations observed in the lake-water samples to determine whether sample contamination was limited to the QC sample. If, based on this comparison, sample contamination was not isolated to the QC sample, the field data were flagged and further interpretation of results was made with this limitation in mind.

Duplicate samples consisted of two samples collected from the same location at the same time, using the same sampling and sample handling procedures. They were labelled and preserved individually and submitted separately to the analytical laboratory for identical analyses. Duplicate samples are used to check within-station variation and the precision of field sampling and analytical methods. Differences between concentrations measured in duplicate water samples were calculated as the relative percent difference (RPD) for each variable. Before calculating the RPD, concentrations below the DL were replaced with 0.5 times the DL value. The RPD was calculated using the following formula:

RPD = (|difference in concentration between duplicate samples| / mean concentration) x 100

The RPD value for a given variable was considered notable if:

- it was greater than 40%; and
- concentrations in one or both samples were greater than or equal to five times the DL.

These criteria are similar to those used by BV Labs for internal QC of laboratory duplicate samples, and take into account the potential for data accuracy error as variable concentrations approach DLs.

The number of variables which exceeded the assessment criteria was compared to the total number of variables analyzed to evaluate analytical precision. The analytical precision was rated as follows:

- high, if less than 10% of the total number of variables were notably different from one another;
- moderate, if 10% to 30% of the total number of variables were notably different from one another; and
- low, if more than 30% of the total number of variables were notably different from one another.

Quality Control Results

Detection Limits

Water quality samples were submitted to BV Labs for analysis. BV Labs is an accredited analytical laboratory and has a dedicated inductively coupled plasma mass spectrometer (ICP-MS) specifically for ultra-low trace metal analysis. The ultra-low analytical DLs can only be obtained on water samples with very low particulate matter (i.e., turbidity less than 0.5 nephelometric turbidity unit [NTU]).

BV Labs used analyte-specific DLs to report results for water quality variables analyzed in 2020. The DLs used by BV Labs in 2020 are listed in Tables B-1 and B-2 (see also Section 2.2, Table 2-2 of the 2020 *Effluent and Water Chemistry Report* [Appendix II]). Deviations from the target DLs and a discussion of potential effects on data quality are as follows:

- Similar to previous years, sulphate was analyzed at a DL of 0.5 mg/L (versus a requested DL of 0.05 mg/L) due to limitations of the current analytical method. BV Labs is currently investigating ways to provide the requested DL. In 2020, samples that were less than the DL for the ICP-MS method (i.e., DL of 0.5 mg/L) were reanalyzed using inductively coupled plasma optical emission spectrometry (ICP-OES) with a DL of 0.05 mg/L. Only the QC blank results were below the DL. As a result, use of the elevated DL does not affect data quality.
- The DL for total ammonia measured by ALS (i.e., 5 µg-N/L) was raised to 13 µg-N/L in one sample (NF4M-3) due to sample matrix interference.
- The DLs for nitrate + nitrite were elevated above the requested values (i.e., 2 µg-N/L requested and 2.2 µg-N/L reported) in all open-water samples (i.e., 67 samples) due to an issue with the calculation used for the DL. BV Labs is currently investigating ways to adjust this calculation. Use of the elevated DL is not expected to affect data quality because the majority of the samples were greater than the DL and the elevated DL is close to the requested DL.
- The DL for dissolved Kjeldahl nitrogen and total dissolved nitrogen (i.e., 20 µg-N/L) was raised to 40 µg-N/L in three samples (NF2M, NF2B, and MF1-3T) and to 100 µg-N/L in one sample (NF4B) in the ice-cover season due to insufficient/limited sample volume.
- The DL for soluble reactive phosphorus (i.e., 1 µg-P/L) was raised to 2 µg-P/L, 5 µg-P/L, 10 µg-P/L, and 20 µg-P/L in MF3-2B, MF3-4M, MF3-2M, and MF3-2B-3, respectively, in the ice-cover season, due to matrix interference.

- The DLs for total and dissolved mercury were lowered below the requested values (i.e., 0.002 µg/L requested, 0.0019 µg/L reported) as a result of an internal audit conducted by BV Labs, where it was recommended the RDL be lowered below the lowest guideline (i.e., 0.002 µg/L).
- The DLs for total and dissolved sulphur were elevated above the requested values (i.e., 0.1 mg/L requested and 0.5 mg/L reported) due to limitations of the current analytical method. BV Labs is currently investigating ways to provide the requested DL. In 2020, samples that were less than the DL for the ICP-MS method (i.e., DL of 0.5 mg/L) were analyzed using ICP-OES with a DL of 0.1 mg/L. Only the QC blank results were below the DL. As a result, use of the elevated DL does not affect data quality.

Blank Samples

Of the 93 variables analyzed during the ice-cover season, two variables (i.e., ammonia and dissolved zinc) were measured in QC blank samples at a concentration above the data quality objective (DQO) of less than five times the DL (Table B-1). Details of the ice-cover blank sample DQO exceedances are as follows:

- Ammonia (ALS) and ammonia (BV) exceeded the DQO in the equipment blank sample prepared at FF2-5B.
- Ammonia (BV) exceeded the DQO in the travel blank assigned to NF3T.
- Dissolved zinc exceeded the DQO in the equipment blank prepared at MF3-5B.

Exceedances of the DQO occurred in 1.0% of the ice-cover blank sample results and, therefore, the blank results indicated acceptable data quality. The variability of ammonia concentrations affected the reliability of the data used in the *AEMP Effluent and Water Chemistry Report*. This is discussed further below (see “Ammonia Investigation”). Concentrations of dissolved zinc were similar to those measured in the lake-water samples. The potential contamination identified for zinc was relatively minor and did not interfere with the evaluation of Action Levels, because concentrations in the NF area were below reference conditions for Lac de Gras despite the potential contamination identified in the blank sample.

During the open-water season, the concentrations of eight (i.e., total dissolved solids (measured), ammonia, sulphate, dissolved aluminum, dissolved copper, dissolved nickel, total and dissolved zinc) of the 93 variables measured in QC blanks were greater than five times the DL (Table B-1). Details of the open-water blank sample DQO exceedances are as follows:

- Total dissolved solids (measured), sulphate, and ammonia (BV), exceeded the DQO in the field blank collected at NF2B.
- Ammonia (ALS) and Ammonia (BV) exceeded the DQO in the travel blank assigned to NF4M.
- Total and dissolved zinc exceeded the DQO in the field blank collected at MF2-3T.
- Dissolved copper and dissolved nickel exceeded the DQO in the travel blank assigned to MF3-3B.
- Dissolved aluminum exceeded the DQO in the equipment blank sample prepared at MF3-6B.

Exceedances of the DQO occurred in 2.6% of the open-water blank sample results and, therefore, the blank results indicated acceptable data quality. Overall, concentrations of total dissolved solids (measured) and sulphate reported in the blank sample were below those measured in the lake-water samples. The variability of ammonia concentrations affected the reliability of the data used in this report. This is discussed further below (see “Ammonia Investigation”). Phosphorus variables are evaluated in the QA/QC Attachment of the *Eutrophication Indicators Report* (Appendix XIII). Some elevated values for dissolved metals were observed in the lake-water samples at greater concentration than the associated total concentration. This is discussed further below (see “Abnormal Results for Dissolved Metals”). Since the AEMP analyses focus on the total metal concentrations, the potential contamination identified for dissolved aluminum, copper, nickel, and zinc did not interfere with the determination of Action Levels.

As the DQO exceedances for these parameters were infrequent, it is unlikely that the contamination found in blank samples affected the reliability of the data used in the AEMP Effluent and Water Chemistry Report.

Field Duplicate Samples

A total of 4 out of 93 water quality variables analyzed in 2020 exceeded the DQO of both the 40% RPD and five times DL criteria for field duplicate samples at least once (Table B-2). These variables included ammonia (BV Labs), ammonia (ALS), total zinc, and dissolved molybdenum. These results were considered notable, because the differences in concentrations between duplicate samples for these analytes (i.e., RPD of 46% to 176%) were appreciably greater than the QC objectives used by BV Labs to identify unacceptable differences between laboratory duplicate samples (i.e., RPD of 20% to 25%). Laboratory duplicates consist of two independently analyzed portions of the same sample and would, therefore, be expected to have lower variability among paired duplicate samples than field duplicates, which consist of two separate grab samples.

In total, 1.1% of the field duplicate data assessed in the duplicate comparison exceeded the DQO, which indicates a high level of analytical precision for the 2020 samples. Therefore, duplicate sample results indicate that data are of acceptable quality. Generally, concentrations in duplicate samples with DQO exceedances were within the range of values reported at other nearby AEMP stations, indicating that the QC issues identified with these variables did not likely interfere with the evaluation of Mine-related effects.

Table B-1 Blank Sample Results, 2020

Parameter	Unit	DL	Ice-Cover									Open-Water						
			NF1M-2	**NF3T-3**	**MF1-1B-1**	**MF1-5B-3**	**MF2-1M-2**	**FF2-5B-1**	**MF3-2B-3**	**MF3-5B-1**	**FFD-1M-2**	**NF2B-2**	**NF4M-3**	**MF1-1B-1**	**MF2-3T-2**	**MF3-3B-3**	**MF3-6B-1**	**FF1-2M-2**
			28-Apr-2020	**20-Apr-2020**	**21-Apr-2020**	**22-Apr-2020**	**27-Apr-2020**	**29-Apr-2020**	**27-Apr-2020**	**26-Apr-2020**	**23-Apr-2020**	**07-Sep-2020**	**29-Aug-2020**	**31-Aug-2020**	**28-Aug-2020**	**22-Aug-2020**	**21-Aug-2020**	**18-Aug-2020**
			Field Blank	**Travel Blank**	**Equipment Blank**	**Travel Blank**	**Field Blank**	**Equipment Blank**	**Travel Blank**	**Equipment Blank**	**Field Blank**	**Field Blank**	**Travel Blank**	**Equipment Blank**	**Field Blank**	**Travel Blank**	**Equipment Blank**	**Field Blank**
Conventional Parameters																		
Total alkalinity as $CaCO_3$	mg/L	0.5	<0.5	-	-	-	<0.5	-	<0.5	<0.5	-	0.66	-	-	0.56	0.7	0.61	-
Specific conductivity	µS/cm	1	<1	-	-	-	<1	-	1.1	<1	-	<1	-	-	<1	<1	<1	-
Total hardness as $CaCO_3$	mg/L	0.5	<0.5	-	-	-	<0.5	-	<0.5	<0.5	-	<0.5	-	-	<0.5	<0.5	<0.5	-
pH - lab	-	-	4.97	-	-	-	5.01	-	4.99	5.02	-	5.45	-	-	5.57	5.59	5.55	-
Total dissolved solids, calculated	mg/L	0.5	0.8	-	-	-	0.7	-	0.9	<0.5	-	1	-	-	<0.5	1.1	1.2	-
Total dissolved solids, measured	mg/L	1	<1	-	-	-	<1	-	<1	<1	-	**9.6**	-	-	<1	1.2	<1	-
Total suspended solids	mg/L	1	<1	-	-	-	1.5	-	<1	<1	-	<1	-	-	1.8	<1	<1	-
Total organic carbon	mg/L	0.2	0.31	-	-	-	0.25	-	0.97	0.38	-	<0.2	-	-	0.33	<0.2	<0.2	-
Turbidity - lab	NTU	0.1	<0.1	-	-	-	<0.1	-	<0.1	<0.1	-	0.21	-	-	<0.1	<0.1	<0.1	-
Major Ions																		
Bicarbonate	mg/L	0.5	<0.5	-	-	-	<0.5	-	<0.5	<0.5	-	0.81	-	-	0.69	0.85	0.74	-
Calcium (dissolved)	mg/L	0.01	0.014	-	-	-	<0.01	-	<0.01	0.021	-	<0.01	-	-	0.013	<0.01	<0.01	-
Carbonate	mg/L	0.5	<0.5	-	-	-	<0.5	-	<0.5	<0.5	-	<0.5	-	-	<0.5	<0.5	<0.5	-
Chloride	mg/L	0.5	0.79	-	-	-	0.7	-	0.92	<0.5	-	<0.5	-	-	<0.5	0.7	0.82	-
Fluoride	mg/L	0.01	<0.01	-	-	-	<0.01	-	<0.01	<0.01	-	<0.01	-	-	<0.01	<0.01	<0.01	-
Hydroxide	mg/L	0.5	<0.5	-	-	-	<0.5	-	<0.5	<0.5	-	<0.5	-	-	<0.5	<0.5	<0.5	-
Magnesium (dissolved)	mg/L	0.005	<0.005	-	-	-	<0.005	-	<0.005	<0.005	-	<0.005	-	-	<0.005	<0.005	<0.005	-
Potassium (dissolved)	mg/L	0.01	<0.01	-	-	-	<0.01	-	<0.01	<0.01	-	<0.01	-	-	<0.01	<0.01	<0.01	-
Sodium (dissolved)	mg/L	0.01	<0.01	-	-	-	<0.01	-	<0.01	<0.01	-	<0.01	-	-	0.011	<0.01	<0.01	-
Sulphate	mg/L	0.05	0.092	-	-	-	<0.05	-	<0.05	<0.05	-	**0.56**	-	-	<0.05	<0.05	<0.05	-
Nutrients																		
Ammonia (ALS)$^{(a)}$	µg-N/L	5	<5	<5	<5	<5	<5	**46.1**	<5	11.7	<5	<5	**285**	<5	15.4	9.4	<5	<5
Ammonia (BV)$^{(a)}$	µg-N/L	5	12	**39**	5.8	<5	22	**27**	<5	8.7	8.3	**160**	**200**	<5	<5	24	<5	<5
Nitrate	µg-N/L	2	<2	-	-	-	<2	-	2	<2	-	<2	-	-	<2	<2	<2	-
Nitrite	µg-N/L	1	3.4	-	-	-	<1	-	<1	<1	-	<1	-	-	<1	<1	<1	-
Nitrate + nitrite	µg-N/L	2	3.4	-	-	-	<2	-	<2	<2	-	<2.2	-	-	<2.2	<2.2	<2.2	-
Total Kjeldahl nitrogen	µg-N/L	20	52	-	-	-	51	-	68	28	-	<20	-	-	<20	<20	43	-
Total dissolved nitrogen	µg-N/L	20	28	-	-	-	<20	-	<20	<20	-	<20	-	-	<20	<20	<20	-
Total nitrogen	µg-N/L	20	56	-	-	-	51	-	68	28	-	<20	-	-	<20	<20	43	-
Soluble reactive phosphorus	µg-P/L	1	<1	-	-	-	1.8	-	<20	<1	-	<1	-	-	<1	1.6	<1	-
Total dissolved phosphorus	µg-P/L	2	<2	-	-	-	<2	-	<2	<2	-	<2	-	-	8.8	<2	<2	-
Total phosphorus	µg-P/L	2	<2	-	-	-	<2	-	<2	<2	-	<2	-	-	<2	<2	<2	-
Total Metals																		
Aluminum	µg/L	0.2	0.29	-	-	-	0.2	-	<0.2	<0.2	-	<0.2	-	-	0.38	<0.2	0.87	-
Antimony	µg/L	0.02	<0.02	-	-	-	<0.02	-	<0.02	<0.02	-	<0.02	-	-	<0.02	<0.02	<0.02	-
Arsenic	µg/L	0.02	<0.02	-	-	-	<0.02	-	<0.02	<0.02	-	<0.02	-	-	<0.02	<0.02	<0.02	-
Barium	µg/L	0.02	<0.02	-	-	-	<0.02	-	<0.02	<0.02	-	<0.02	-	-	0.036	<0.02	<0.02	-

Table B-1 Blank Sample Results, 2020 (continued)

Parameter	Unit	DL	Ice-Cover									Open-Water						
			NF1M-2	NF3T-3	MF1-1B-1	MF1-5B-3	MF2-1M-2	FF2-5B-1	MF3-2B-3	MF3-5B-1	FFD-1M-2	NF2B-2	NF4M-3	MF1-1B-1	MF2-3T-2	MF3-3B-3	MF3-6B-1	FF1-2M-2
			28-Apr-2020	20-Apr-2020	21-Apr-2020	22-Apr-2020	27-Apr-2020	29-Apr-2020	27-Apr-2020	26-Apr-2020	23-Apr-2020	07-Sep-2020	29-Aug-2020	31-Aug-2020	28-Aug-2020	22-Aug-2020	21-Aug-2020	18-Aug-2020
			Field Blank	Travel Blank	Equipment Blank	Travel Blank	Field Blank	Equipment Blank	Travel Blank	Equipment Blank	Field Blank	Field Blank	Travel Blank	Equipment Blank	Field Blank	Travel Blank	Equipment Blank	Field Blank
Beryllium	µg/L	0.01	<0.01	-	-	-	<0.01	-	<0.01	<0.01	-	<0.01	-	-	<0.01	<0.01	<0.01	-
Bismuth	µg/L	0.005	<0.005	-	-	-	<0.005	-	<0.005	<0.005	-	<0.005	-	-	<0.005	<0.005	<0.005	-
Boron	µg/L	5	<5	-	-	-	<5	-	<5	<5	-	<5	-	-	<5	<5	<5	-
Cadmium	µg/L	0.005	<0.005	-	-	-	<0.005	-	<0.005	<0.005	-	<0.005	-	-	<0.005	<0.005	<0.005	-
Calcium	mg/L	0.01	<0.01	-	-	-	<0.01	-	<0.01	<0.01	-	<0.01	-	-	<0.01	<0.01	<0.01	-
Chromium	µg/L	0.05	<0.05	-	-	-	<0.05	-	<0.05	<0.05	-	<0.05	-	-	<0.05	<0.05	<0.05	-
Cobalt	µg/L	0.005	<0.005	-	-	-	<0.005	-	<0.005	<0.005	-	0.0063	-	-	<0.005	<0.005	<0.005	-
Copper	µg/L	0.05	<0.05	-	-	-	<0.05	-	<0.05	<0.05	-	<0.05	-	-	<0.05	<0.05	<0.05	-
Iron	µg/L	1	<1	-	-	-	<1	-	<1	<1	-	<1	-	-	<1	<1	<1	-
Lead	µg/L	0.005	<0.005	-	-	-	<0.005	-	<0.005	<0.005	-	<0.005	-	-	<0.005	<0.005	<0.005	-
Lithium	µg/L	0.5	<0.5	-	-	-	<0.5	-	<0.5	<0.5	-	<0.5	-	-	<0.5	<0.5	<0.5	-
Magnesium	mg/L	0.005	<0.005	-	-	-	<0.005	-	<0.005	<0.005	-	<0.005	-	-	<0.005	<0.005	<0.005	-
Manganese	µg/L	0.05	<0.05	-	-	-	<0.05	-	<0.05	<0.05	-	<0.05	-	-	<0.05	<0.05	<0.05	-
Mercury	µg/L	0.0019	<0.0019	-	-	-	<0.0019	-	<0.0019	<0.0019	-	<0.0019	-	-	<0.0019	<0.0019	<0.0019	-
Molybdenum	µg/L	0.05	<0.05	-	-	-	<0.05	-	<0.05	<0.05	-	<0.05	-	-	<0.05	<0.05	<0.05	-
Nickel	µg/L	0.02	<0.02	-	-	-	<0.02	-	<0.02	<0.02	-	<0.02	-	-	0.045	<0.02	<0.02	-
Potassium	mg/L	0.01	<0.01	-	-	-	<0.01	-	<0.01	<0.01	-	<0.01	-	-	<0.01	<0.01	0.01	-
Selenium	µg/L	0.04	<0.04	-	-	-	<0.04	-	<0.04	<0.04	-	<0.04	-	-	<0.04	<0.04	<0.04	-
Silicon	µg/L	50	<50	-	-	-	<50	-	<50	<50	-	<50	-	-	<50	<50	<50	-
Silver	µg/L	0.005	<0.005	-	-	-	<0.005	-	<0.005	<0.005	-	<0.005	-	-	<0.005	<0.005	<0.005	-
Sodium	mg/L	0.01	<0.01	-	-	-	<0.01	-	<0.01	<0.01	-	<0.01	-	-	<0.01	<0.01	<0.01	-
Strontium	µg/L	0.05	<0.05	-	-	-	<0.05	-	<0.05	<0.05	-	<0.05	-	-	<0.05	<0.05	<0.05	-
Sulphur	mg/L	0.1	<0.1	-	-	-	<0.1	-	<0.1	<0.1	-	<0.1	-	-	<0.1	<0.1	<0.1	-
Thallium	µg/L	0.002	<0.002	-	-	-	<0.002	-	<0.002	<0.002	-	<0.002	-	-	<0.002	<0.002	<0.002	-
Tin	µg/L	0.01	<0.01	-	-	-	<0.01	-	<0.01	0.014	-	<0.01	-	-	<0.01	<0.01	0.024	-
Titanium	µg/L	0.5	<0.5	-	-	-	<0.5	-	<0.5	<0.5	-	<0.5	-	-	<0.5	<0.5	<0.5	-
Uranium	µg/L	0.002	<0.002	-	-	-	<0.002	-	<0.002	<0.002	-	<0.002	-	-	<0.002	<0.002	<0.002	-
Vanadium	µg/L	0.05	<0.05	-	-	-	<0.05	-	<0.05	<0.05	-	<0.05	-	-	<0.05	<0.05	<0.05	-
Zinc	µg/L	0.1	<0.1	-	-	-	<0.1	-	<0.1	<0.1	-	<0.1	-	-	**1.12**	<0.1	<0.1	-
Zirconium	µg/L	0.05	<0.05	-	-	-	<0.05	-	<0.05	<0.05	-	<0.05	-	-	<0.05	<0.05	<0.05	-
Dissolved Metals																		
Aluminum	µg/L	0.2	0.23	-	-	-	<0.2	-	<0.2	0.31	-	<0.2	-	-	0.23	<0.2	**1.87**	-
Antimony	µg/L	0.02	<0.02	-	-	-	<0.02	-	<0.02	<0.02	-	<0.02	-	-	<0.02	<0.02	<0.02	-
Arsenic	µg/L	0.02	<0.02	-	-	-	<0.02	-	<0.02	<0.02	-	<0.02	-	-	<0.02	<0.02	<0.02	-
Barium	µg/L	0.02	<0.02	-	-	-	0.02	-	<0.02	0.022	-	<0.02	-	-	0.027	<0.02	<0.02	-
Beryllium	µg/L	0.01	<0.01	-	-	-	<0.01	-	<0.01	<0.01	-	<0.01	-	-	<0.01	<0.01	<0.01	-
Bismuth	µg/L	0.005	<0.005	-	-	-	<0.005	-	<0.005	<0.005	-	<0.005	-	-	<0.005	<0.005	<0.005	-
Boron	µg/L	5	<5	-	-	-	<5	-	<5	<5	-	<5	-	-	<5	5.5	5.2	-
Cadmium	µg/L	0.005	<0.005	-	-	-	<0.005	-	<0.005	<0.005	-	<0.005	-	-	<0.005	<0.005	<0.005	-
Chromium	µg/L	0.05	<0.05	-	-	-	<0.05	-	0.073	<0.05	-	<0.05	-	-	<0.05	<0.05	0.076	-
Cobalt	µg/L	0.005	<0.005	-	-	-	<0.005	-	<0.005	<0.005	-	<0.005	-	-	0.0066	<0.005	<0.005	-
Copper	µg/L	0.05	<0.05	-	-	-	<0.05	-	<0.05	<0.05	-	<0.05	-	-	<0.05	**0.325**	<0.05	-
Iron	µg/L	1	<1	-	-	-	<1	-	<1	<1	-	<1	-	-	<1	2.6	<1	-

Table B-1 Blank Sample Results, 2020 (continued)

Parameter	Unit	DL	Ice-Cover									Open-Water						
			NF1M-2	NF3T-3	MF1-1B-1	MF1-5B-3	MF2-1M-2	FF2-5B-1	MF3-2B-3	MF3-5B-1	FFD-1M-2	NF2B-2	NF4M-3	MF1-1B-1	MF2-3T-2	MF3-3B-3	MF3-6B-1	FF1-2M-2
			28-Apr-2020	20-Apr-2020	21-Apr-2020	22-Apr-2020	27-Apr-2020	29-Apr-2020	27-Apr-2020	26-Apr-2020	23-Apr-2020	07-Sep-2020	29-Aug-2020	31-Aug-2020	28-Aug-2020	22-Aug-2020	21-Aug-2020	18-Aug-2020
			Field Blank	Travel Blank	Equipment Blank	Travel Blank	Field Blank	Equipment Blank	Travel Blank	Equipment Blank	Field Blank	Field Blank	Travel Blank	Equipment Blank	Field Blank	Travel Blank	Equipment Blank	Field Blank
Lead	µg/L	0.005	<0.005	-	-	-	<0.005	-	<0.005	<0.005	-	<0.005	-	-	<0.005	<0.005	<0.005	-
Lithium	µg/L	0.5	<0.5	-	-	-	<0.5	-	<0.5	<0.5	-	<0.5	-	-	<0.5	<0.5	<0.5	-
Manganese	µg/L	0.05	<0.05	-	-	-	<0.05	-	0.05	<0.05	-	<0.05	-	-	<0.05	<0.05	<0.05	-
Mercury	µg/L	0.0019	<0.0019	-	-	-	<0.0019	-	<0.0019	<0.0019	-	<0.0019	-	-	<0.0019	<0.0019	<0.0019	-
Molybdenum	µg/L	0.05	<0.05	-	-	-	<0.05	-	<0.05	<0.05	-	<0.05	-	-	<0.05	<0.05	<0.05	-
Nickel	µg/L	0.02	<0.02	-	-	-	<0.02	-	<0.02	0.039	-	<0.02	-	-	<0.02	**2.8**	0.03	-
Selenium	µg/L	0.04	<0.04	-	-	-	<0.04	-	<0.04	<0.04	-	<0.04	-	-	<0.04	<0.04	<0.04	-
Silicon	µg/L	50	<50	-	-	-	<50	-	<50	<50	-	<50	-	-	<50	<50	<50	-
Silver	µg/L	0.005	<0.005	-	-	-	<0.005	-	<0.005	<0.005	-	<0.005	-	-	<0.005	<0.005	<0.005	-
Strontium	µg/L	0.05	<0.05	-	-	-	<0.05	-	<0.05	<0.05	-	<0.05	-	-	<0.05	<0.05	0.065	-
Sulphur	mg/L	0.1	<0.1	-	-	-	<0.1	-	<0.1	<0.1	-	<0.1	-	-	<0.1	0.12	<0.1	-
Thallium	µg/L	0.002	<0.002	-	-	-	<0.002	-	<0.002	<0.002	-	<0.002	-	-	<0.002	0.0022	<0.002	-
Tin	µg/L	0.01	<0.01	-	-	-	<0.01	-	<0.01	<0.01	-	<0.01	-	-	<0.01	0.036	0.036	-
Titanium	µg/L	0.5	<0.5	-	-	-	<0.5	-	<0.5	<0.5	-	<0.5	-	-	<0.5	<0.5	<0.5	-
Uranium	µg/L	0.002	<0.002	-	-	-	<0.002	-	<0.002	<0.002	-	<0.002	-	-	0.0021	<0.002	<0.002	-
Vanadium	µg/L	0.05	<0.05	-	-	-	<0.05	-	<0.05	<0.05	-	<0.05	-	-	<0.05	<0.05	<0.05	-
Zinc	µg/L	0.1	<0.1	-	-	-	<0.1	-	<0.1	**1.45**	-	<0.1	-	-	**0.51**	<0.1	<0.1	-
Zirconium	µg/L	0.05	0.051	-	-	-	<0.05	-	<0.05	<0.05	-	<0.05	-	-	<0.05	<0.05	<0.05	-

a) Based on the results of the ammonia investigation, the ALS ammonia dataset was used in both seasons (see the “Ammonia Investigation” section for further details).

Note: **Bold** values represent an exceedance of the data quality objective for blank samples (concentration greater than 5 times the DL).

NTU = nephelometric turbidity units; µg-N/L = micrograms nitrogen per litre; µg-P/L = micrograms phosphorus per litre; µS/cm = microsiemens per centimetre; DL = detection limit; $CaCO_3$ = calcium carbonate; NF = near-field; MF = mid-field; FF = far-field.

Table B-2 Duplicate Sample Results, 2020

Parameter	Unit	MDL	NF4M		RPD	MF3-6M		RPD	NF5T		RPD	MF3-7B		RPD
			Sample	Duplicate		Sample	Duplicate		Sample	Duplicate		Sample	Duplicate	
			28-Apr-20	28-Apr-20		26-Apr-20	26-Apr-20		29-Aug-20	29-Aug-20		21-Aug-20	21-Aug-20	
Conventional Parameters														
Total Alkalinity	mg/L	0.5	5.2	5.1	2.1%	4.05	3.97	2.0%	5.43	5.22	3.9%	4.14	4.15	0.2%
Specific Conductivity - lab	µS/cm	1	47.3	47.6	0.6%	29.2	29.1	0.3%	39.9	40	0.3%	27	26.8	0.7%
Total Hardness as CaCO3	mg/L	0.5	12.7	11.4	11%	8.58	7.8	9.5%	9.08	9.2	1.3%	7.08	7.07	0.1%
pH	-	-	6.64	6.74	23%	6.66	6.66	0.0%	6.78	6.77	2.3%	6.76	6.73	6.9%
Total Dissolved Solids, Calculated	mg/L	0.5	23.9	23.3	2.5%	14.9	14.5	2.7%	21.6	19.4	10.7%	13.6	13.3	2.2%
Total Dissolved Solids, Measured	mg/L	1	31.2	29.2	6.6%	20.4	19.2	6.1%	24	22.4	6.9%	9.6	12	22.2%
Total Suspended Solids	mg/L	1	1.3	<1	-	<1	<1	-	<1	<1	-	1.2	1.5	-
Total Organic Carbon	mg/L	0.2	2.1	2.2	-	2.1	2.2	-	2.2	2.3	4.4%	1.9	2.1	10.0%
Turbidity	NTU	0.1	0.27	0.11	-	<0.1	<0.1	-	0.26	0.27	-	0.23	<0.1	-
Major Ions														
Bicarbonate	mg/L	0.5	6.36	6.22	2.2%	4.94	4.85	1.8%	6.63	6.37	4.0%	5.05	5.07	0.4%
Calcium	mg/L	0.01	2.98	2.63	13%	1.58	1.63	3.1%	1.95	1.92	1.6%	1.48	1.49	0.7%
Carbonate	mg/L	0.5	<0.5	<0.5	-	<0.5	<0.5	-	<0.5	<0.5	-	<0.5	<0.5	-
Chloride	mg/L	0.5	6.3	6.2	1.6%	2.6	2.4	8.0%	4.1	4.2	2.4%	2.7	2.6	3.8%
Fluoride	mg/L	0.01	0.033	0.034	-	0.031	0.028	-	0.03	0.031	-	0.025	0.027	-
Hydroxide	mg/L	0.5	<0.5	<0.5	-	<0.5	<0.5	-	<0.5	<0.5	-	<0.5	<0.5	-
Magnesium	mg/L	0.005	1.4	1.39	0.7%	0.983	0.972	1.1%	1.08	1.1	1.8%	0.852	0.828	2.9%
Potassium	mg/L	0.01	1.19	1.16	2.6%	0.84	0.855	1.8%	1.06	1.06	0.0%	0.746	0.722	3.3%
Sodium	mg/L	0.01	3.65	3.61	1.1%	1.72	1.76	2.3%	2.73	2.69	1.5%	1.48	1.44	2.7%
Sulphate	mg/L	0.05	4.7	4.7	0.0%	4.6	4.4	4.4%	7.2	5	36.1%	3.8	3.8	0.0%
Nutrients														
Ammonia (ALS)(a)	µg-N/L	5	19.6	26.8	31%	17.2	19.8	-	5.4	6.5	18.5%	23.2	<5	**129%**
Ammonia (BV)(a)	µg-N/L	5	180	24	**153%**	22	35	**46%**	<5	6.6	-	<5	8.3	-
Nitrate	µg-N/L	2	120	120	0.0%	4.1	4	-	47	49	4.2%	2.2	<2	-
Nitrite	µg-N/L	1	2.7	3.3	-	2.6	4.5	-	3.1	3.1	-	1.9	<1	-
Nitrate + nitrite	µg-N/L	2	120	120	0.0%	6.6	8.5	-	50	52	3.9%	4.1	<2.2	-
Total Kjeldahl Nitrogen	µg-N/L	20	220	220	0.0%	170	160	6.1%	200	230	14.0%	130	130	0.0%
Total Dissolved Nitrogen	µg-N/L	20	300	300	0.0%	140	150	6.9%	210	280	28.6%	160	120	28.6%
Total Nitrogen	µg-N/L	20	350	350	0.0%	170	160	6.1%	250	280	11.3%	130	130	0.0%
Soluble Reactive Phosphorus	µg-P/L	1	<1	<1	-	<1	<1	-	<1	<1	-	<1	<1	-
Total Dissolved Phosphorus	µg-P/L	2	<2	<2	-	<2	<2	-	<2	<2	-	<2	<2	-
Total Phosphorus	µg-P/L	2	2	<2	-	5.2	<2	-	<2	3.2	-	<2	<2	-
Total Metals														
Aluminum	µg/L	0.2	5.9	5.84	1.0%	3.02	2.59	15.3%	5.56	5.77	3.7%	11.6	12.4	6.7%
Antimony	µg/L	0.02	0.045	0.033	-	<0.02	<0.02	-	0.03	<0.02	-	<0.02	<0.02	-
Arsenic	µg/L	0.02	0.323	0.242	28.7%	0.18	0.198	9.5%	0.241	0.237	1.7%	0.191	0.19	0.5%

Table B-2 Duplicate Sample Results, 2020 (continued)

Parameter	Unit	MDL	NF4M		RPD	MF3-6M		RPD	NF5T		RPD	MF3-7B		RPD
			Sample	Sample		Sample	Duplicate		Sample	Duplicate		Sample	Duplicate	
			28-Apr-20	28-Apr-20		26-Apr-20	26-Apr-20		29-Aug-20	29-Aug-20		21-Aug-20	21-Aug-20	
Barium	µg/L	0.02	4.64	4.52	2.6%	2.32	2.21	4.9%	2.84	2.91	2.4%	1.9	1.83	3.8%
Beryllium	µg/L	0.01	<0.01	<0.01	-	<0.01	<0.01	-	<0.01	<0.01	-	<0.01	<0.01	-
Bismuth	µg/L	0.005	<0.005	<0.005	-	<0.005	<0.005	-	<0.005	0.0125	-	<0.005	<0.005	-
Boron	µg/L	5	<5	<5	-	<5	<5	-	<5	<5	-	<5	<5	-
Cadmium	µg/L	0.005	<0.005	<0.005	-	<0.005	<0.005	-	<0.005	<0.005	-	<0.005	<0.005	-
Calcium	mg/L	0.01	2.73	2.45	10.8%	1.66	1.50	10.1%	1.87	1.90	1.6%	1.45	1.46	0.7%
Chromium	µg/L	0.05	0.393	0.263	39.6%	<0.05	<0.05	-	0.057	<0.05	-	<0.05	<0.05	-
Cobalt	µg/L	0.005	0.0177	0.0165	-	0.022	0.0254	14.3%	0.0382	0.0295	25.7%	0.0922	0.073	23.2%
Copper	µg/L	0.05	0.747	0.657	12.8%	0.692	0.569	19.5%	0.53	0.523	1.3%	0.516	0.52	0.8%
Iron	µg/L	1	3.4	2.6	-	2.6	2.1	-	5.2	4.4	16.7%	23.3	24.8	6.2%
Lead	µg/L	0.005	<0.005	<0.005	-	<0.005	<0.005	-	<0.005	<0.005	-	<0.005	<0.005	-
Lithium	µg/L	0.5	2.26	2.27	0.4%	1.75	1.67	4.7%	1.32	1.29	-	1.39	1.34	-
Magnesium	mg/L	0.005	1.43	1.28	11.1%	1.08	0.986	9.1%	1.07	1.08	0.9%	0.84	0.835	0.6%
Manganese	µg/L	0.05	2.15	2.08	3.3%	2.46	2.53	2.8%	1.97	1.69	15.3%	5.4	5.44	0.7%
Mercury	µg/L	0.002	<0.0019	<0.0019	-	<0.0019	<0.0019	-	<0.0019	<0.0019	-	<0.0019	<0.0019	-
Molybdenum	µg/L	0.05	1.06	1.02	3.8%	0.246	0.241	-	0.79	0.825	4.3%	0.121	0.125	-
Nickel	µg/L	0.02	0.946	0.809	15.6%	1.18	1.18	0.0%	0.729	0.718	1.5%	1.02	0.943	7.8%
Potassium	mg/L	0.01	1.21	1.04	15.1%	0.978	0.905	7.8%	1.030	1.060	2.9%	0.735	0.728	1.0%
Selenium	µg/L	0.04	<0.04	<0.04	-	<0.04	<0.04	-	<0.04	<0.04	-	<0.04	<0.04	-
Silicon	µg/L	50	174	164	-	<50	<50	-	57	53	-	<50	<50	-
Silver	µg/L	0.005	<0.005	<0.005	-	<0.005	<0.005	-	<0.005	<0.005	-	<0.005	<0.005	-
Sodium	mg/L	0.01	3.62	3.34	8.0%	1.88	1.73	8.3%	2.65	2.67	0.8%	1.45	1.45	0.0%
Strontium	µg/L	0.05	46.7	41.7	11.3%	17.1	16.1	6.0%	25.5	25.9	1.6%	13.1	12.9	1.5%
Sulphur	mg/L	0.5	2.27	1.93	16.2%	2.09	2.15	2.8%	1.31	1.24	5.5%	0.64	0.64	0.0%
Thallium	µg/L	0.002	<0.002	<0.002	-	0.0032	<0.002	-	<0.002	<0.002	-	<0.002	0.0028	-
Tin	µg/L	0.01	0.025	0.011	-	<0.01	<0.01	-	<0.01	<0.01	-	<0.01	<0.01	-
Titanium	µg/L	0.5	<0.5	<0.5	-	<0.5	<0.5	-	<0.5	<0.5	-	<0.5	<0.5	-
Uranium	µg/L	0.002	0.169	0.158	6.7%	0.0455	0.0375	19.3%	0.126	0.138	9.1%	0.0334	0.0325	2.7%
Vanadium	µg/L	0.05	0.052	<0.05	-	<0.05	0.054	-	<0.05	<0.05	-	<0.05	0.055	-
Zinc	µg/L	0.1	0.31	0.15	-	1.18	1.19	0.8%	2.89	0.27	**166%**	<0.1	<0.1	-
Zirconium	µg/L	0.05	<0.05	0.067	-	0.058	<0.05	-	<0.05	<0.05	-	<0.05	<0.05	-
Dissolved Metals														
Aluminum	µg/L	0.2	5.97	5.33	11.3%	2.21	2.42	9.1%	4.43	4.43	0.0%	9.04	9.72	7.2%
Antimony	µg/L	0.02	0.02	<0.02	-	0.035	0.031	-	0.028	0.028	-	<0.02	<0.02	-
Arsenic	µg/L	0.02	0.285	0.277	2.8%	0.197	0.232	16.3%	0.293	0.327	11.0%	0.186	0.188	1.1%
Barium	µg/L	0.02	4.76	4.48	6.1%	2.15	2.2	2.3%	2.89	2.94	1.7%	1.9	1.81	4.9%

Table B-2 Duplicate Sample Results, 2020 (continued)

Parameter	Unit	MDL	NF4M		RPD	MF3-6M		RPD	NF5T		RPD	MF3-7B		RPD
			Sample	Sample		Sample	Duplicate		Sample	Duplicate		Sample	Duplicate	
			28-Apr-20	28-Apr-20		26-Apr-20	26-Apr-20		29-Aug-20	29-Aug-20		21-Aug-20	21-Aug-20	
Beryllium	µg/L	0.01	<0.01	<0.01	-	<0.01	<0.01	-	<0.01	<0.01	-	<0.01	<0.01	-
Bismuth	µg/L	0.005	<0.005	<0.005	-	<0.005	<0.005	-	<0.005	<0.005	-	<0.005	<0.005	-
Boron	µg/L	5	<5	<5	-	<5	<5	-	<5	<5	-	<5	<5	-
Cadmium	µg/L	0.005	<0.005	<0.005	-	<0.005	<0.005	-	<0.005	<0.005	-	<0.005	<0.005	-
Chromium	µg/L	0.05	<0.05	<0.05	-	<0.05	<0.05	-	0.058	0.051	-	<0.05	<0.05	-
Cobalt	µg/L	0.005	0.0116	0.0188	-	0.0171	0.0199	-	0.0116	0.0064	-	0.0504	0.0642	24.1%
Copper	µg/L	0.05	0.633	0.634	0.2%	0.596	0.555	7.1%	0.49	0.495	1.0%	0.487	0.483	0.8%
Iron	µg/L	1	1.3	1.2	-	1.3	1.7	-	1.8	2.1	-	13.2	13.8	4.4%
Lead	µg/L	0.005	<0.005	<0.005	-	<0.005	<0.005	-	<0.005	<0.005	-	<0.005	<0.005	-
Lithium	µg/L	0.5	2.36	2.25	-	1.58	1.62	-	1.34	1.35	-	1.36	1.35	-
Manganese	µg/L	0.05	2.32	2.06	11.9%	1.04	1.26	19.1%	0.351	0.292	18.4%	2.98	2.96	0.7%
Mercury	µg/L	0.002	<0.0019	<0.0019	-	<0.0019	<0.0019	-	<0.0019	<0.0019	-	<0.0019	<0.0019	-
Molybdenum	µg/L	0.05	1.14	1.05	8.2%	0.233	2.23	**162%**	0.839	0.852	1.5%	0.108	0.09	-
Nickel	µg/L	0.02	0.735	0.782	6.2%	0.952	0.961	0.9%	0.71	0.682	4.0%	0.901	0.898	0.3%
Selenium	µg/L	0.04	<0.04	<0.04	-	<0.04	<0.04	-	<0.04	<0.04	-	<0.04	<0.04	-
Silicon	µg/L	50	195	177	-	<50	<50	-	58	55	-	<50	<50	-
Silver	µg/L	0.005	<0.005	<0.005	-	<0.005	<0.005	-	<0.005	<0.005	-	<0.005	<0.005	-
Strontium	µg/L	0.05	43.4	45.1	3.8%	16.2	16.6	2.4%	26.5	26.7	0.8%	13.1	12.6	3.9%
Sulphur	mg/L	0.5	1.98	2.14	7.8%	1.32	1.17	12.0%	1.35	1.27	6.1%	0.67	0.64	4.6%
Thallium	µg/L	0.002	<0.002	<0.002	-	<0.002	<0.002	-	<0.002	<0.002	-	0.033	0.0343	3.6%
Tin	µg/L	0.01	<0.01	<0.01	-	<0.01	<0.01	-	<0.01	<0.01	-	<0.01	<0.01	-
Titanium	µg/L	0.5	<0.5	<0.5	-	<0.5	<0.5	-	<0.5	<0.5	-	<0.5	<0.5	-
Uranium	µg/L	0.002	0.175	0.158	10.2%	0.0329	0.0363	9.8%	0.119	0.119	0.0%	0.0301	0.029	3.7%
Vanadium	µg/L	0.05	<0.05	<0.05	-	<0.05	<0.05	-	<0.05	<0.05	-	0.062	0.075	-
Zinc	µg/L	0.1	<0.1	0.26	-	2.05	2.25	9.3%	0.43	0.48	-	0.69	0.65	6.0%
Zirconium	µg/L	0.05	0.076	<0.05	-	<0.05	<0.05	-	<0.05	<0.05	-	<0.05	<0.05	-
Calculated Quantities														
RPD values over 20%	%	-	-	-	1.1	-	-	2.1	-	-	1.1	-	-	1.1
RPD values over 20%	#	-	-	-	1	-	-	2	-	-	1	-	-	1

a) Based on the results of the ammonia investigation, the ALS ammonia dataset was used in both seasons (see the “Ammonia Investigation” section for more details).

Note: Bold RPD values are greater than 40%, and concentrations in one or both samples that were greater than or equal to five times the DL.

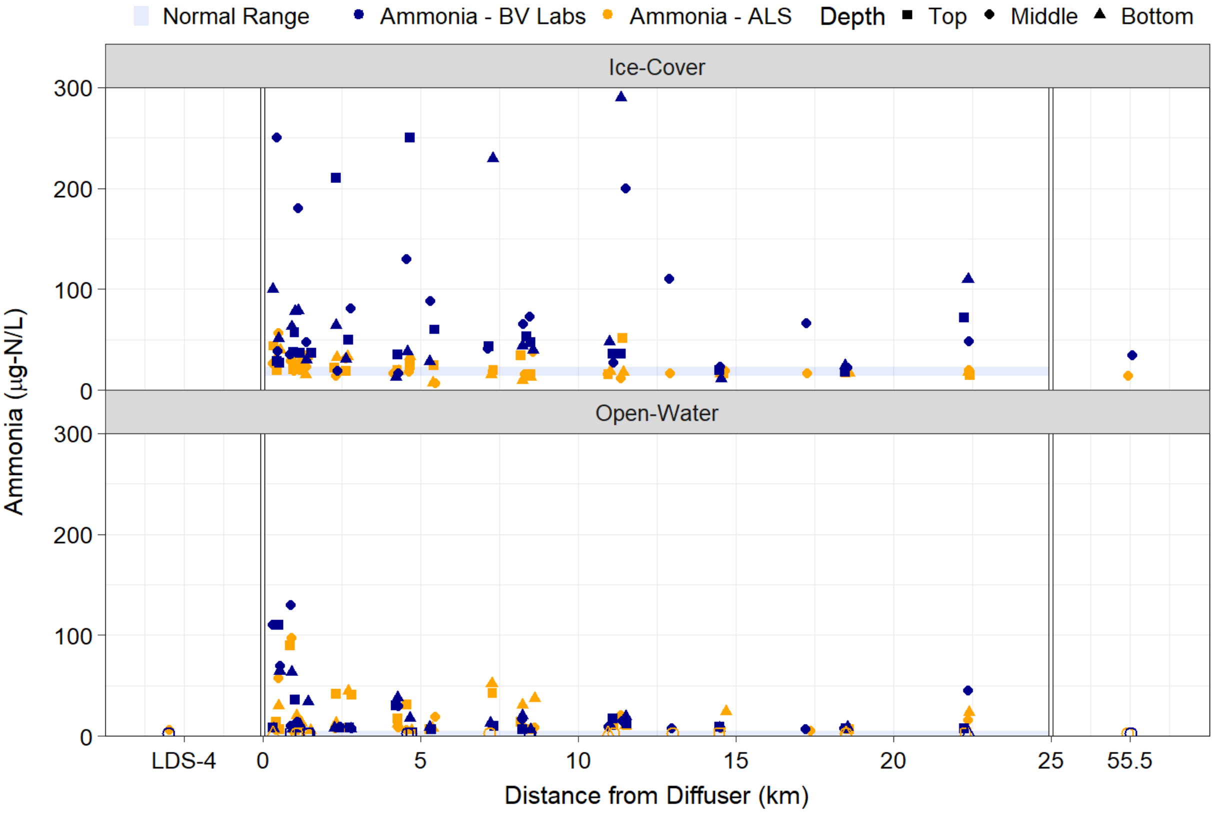
RPD = relative percent difference; - = not applicable; NTU = nephelometric turbidity unit; µg-N/L = micrograms nitrogen per litre; µg-P/L = micrograms phosphorus per litre; µS/cm = microsiemens per centimetre; DL = detection limit; NF = near-field; MF = mid-field; FF = far-field.

Ammonia Investigation

The reader is directed to Appendix 4B of the *2014 to 2016 Aquatic Effects Re-evaluation Report Version 1.1* (Golder 2019a) and Appendix B of the 2017, 2018, and 2019 AEMP annual effluent and water chemistry reports (Golder 2018, 2019b, 2020) for a review of the history of the ammonia contamination issue for the AEMP prior to 2020. The following text provides a summary of efforts that took place in 2020 and the selection of ammonia data used for analysis in the *2020 AEMP Annual Report*.

Data quality issues with ammonia continue to be a concern in 2020, with incidental occurrences of contamination in blank samples, and relatively large variability between duplicate samples. In 2020, DDMI sent lake water quality samples to both BV Labs and ALS for analysis of ammonia, consistent with previous years. A comparison of the available ammonia data for Lac de Gras is shown in Figure B-1.

Figure B-1 Ammonia Concentrations in Lac de Gras Measured by BV and ALS, 2020



T = top depth; M = middle depth; B = bottom depth; µg-N/L = micrograms nitrogen per litre; <DL = less than detection limit.

BV Labs completed a review of the ice-cover season ammonia data and found that the total ammonia data from BV Labs was contaminated. The source of the contamination is unknown; however, most of the trip blank samples were non-detect, suggesting the contamination was not introduced during the analysis process as trip blanks are treated identically to non-QC samples. To further investigate data quality issues identified for ammonia, BV Labs completed an inter-laboratory comparison study evaluating differences in ammonia results for the 2020 ice-cover samples analyzed by BV Labs and ALS. The study is included in Annex A (following Attachment B). The key results of the study were that:

(1) A high level of contamination was identified in the BV Labs total ammonia samples.

(2) The ALS ice-cover data is subject to a low level of contamination resulting in a high bias; however, the dataset is internally consistent and comparable to the 2018 ice-cover dataset.

(3) Evidence suggests that an ammonia source other than the lake water itself continues to be an issue and that the sulphuric acid preservative is part of the problem. It is recommended that the AEMP ammonia samples be collected in unpreserved containers and be preserved at the lab under controlled conditions.

Since total ammonia data generated by ALS for the ice-cover season had fewer data quality issues than the total ammonia data generated by BV Labs, as well as the results of the ice-cover inter-laboratory comparison study, the ALS ice-cover data was chosen for use in the data analyses, tables, and figures completed in support of the 2020 AEMP Annual Report.

As recommended in the 2020 ice-cover inter-laboratory comparison study, BV Lab ammonia samples for the 2020 open-water season were submitted unpreserved, due to concerns with contamination from the preservative observed in previous sampling rounds. After arriving at the laboratory, samples were preserved under controlled conditions. Considering the low pH, low biological activity, and demonstrated stability over 14 days with respect to ammonia for the AEMP samples, there is negligible chance of loss over the estimated 5 or 6 days between sampling and preservation at the laboratory. This is the same protocol as is currently used successfully for metals.

To further investigate data quality issues identified for ammonia, BV Labs completed an inter-laboratory comparison study evaluating differences in ammonia results for the 2020 open-water samples analyzed by BV Labs and ALS. The study is included in Annex B (following Attachment B). The key results of the study were that:

(1) Both datasets are subject to high outliers. However, the high bias the BV Labs NF2 samples would introduce is greater than the likely low bias from the ALS samples. As a result, ALS data was recommended for reporting.

(2) Evidence suggests that both the ALS and BV trip blanks were exposed to a significant source of ammonia contamination during sample collection, transport, or storage. As a result, BV Labs will commence detailed studies of possible contamination from coolers, packing materials, and other sources, as well as the protocols for preparation of trip blanks and ammonia-free water.

(3) Continued use of unpreserved vials is recommended.

Based on these results, the recommendation to use the ALS data for the open-water season was accepted: ALS open-water data was used in the data analyses, tables, and figures completed in support of the 2020 AEMP Annual Report.

The DL required for ammonia (i.e., 0.005 mg/L) for this AEMP is at the absolute limit of instrument sensitivity, and as a result, concentrations measured close to the DL are subject to large uncertainty. Especially at low levels, ammonia presents issues with respect to potential contamination, because it is airborne. Previous studies have shown that airborne ammonia contamination can be introduced over time into unopened containers (Golder 2019b). The 2020 interlaboratory comparison studies also included some initiatives that BV Labs is undertaking to improve ammonia results:

- Sample handling techniques to minimize lab artifacts including pipetting from the sample vial into the instrument vial, search for ammonia-free gloves, and total segregation of low-level samples.
- Studies continue on finding an ammonia-free bottle cap. A cap is currently being tested that yielded non-detectable results under stringent leaching conditions.
- Evaluate the impact of varying levels of total suspended solids (TSS) on ammonia results. The colourimetric methods use a light beam that is passed through the sample; the concentration of the analyte is proportional to the light absorbed. It may be possible that even the very low levels of particulate material in unfiltered samples are causing a physical interference by scattering some of the light beam, thereby causing a positive interference.

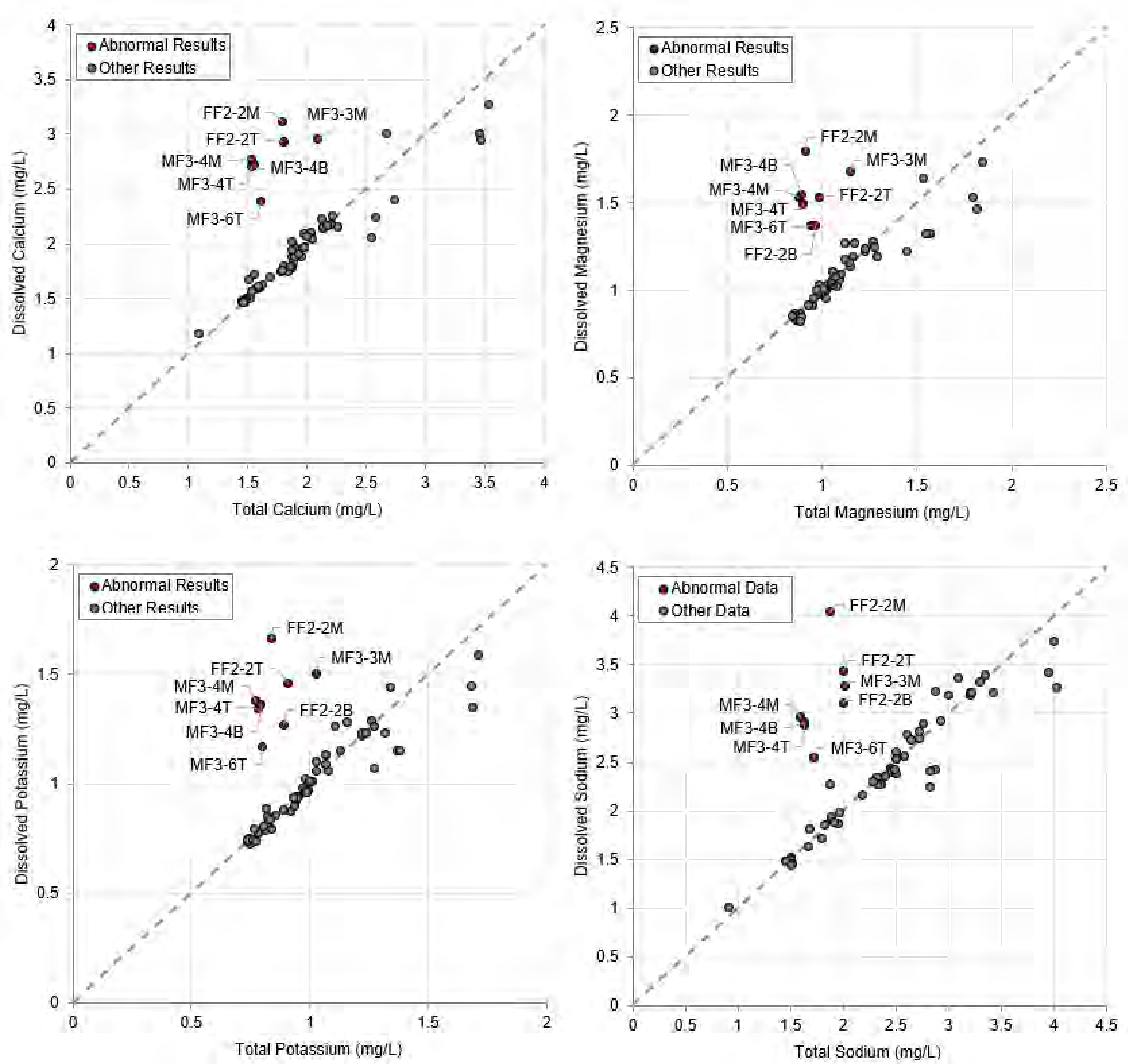
The recommendations and conclusions outlined in the inter-laboratory comparison study are those of BV Labs and do not necessarily reflect DDMI's plan for the AEMP. However, the information gathered by these studies is valuable and will be used in future decision-making related to sampling and analysis of samples for ammonia, and reporting for the AEMP. DDMI will continue to work with the analytical laboratory to determine a path forward for the ammonia analysis for future monitoring. More work is planned in 2021 to help determine the path forward. Duplicate samples will again be provided to BV Labs and ALS for analysis in the ice-cover season of 2021.

Abnormal Results for Dissolved Metals

In 2020, abnormal results were identified in open-water AEMP samples analyzed for dissolved metals. Initial graphical evaluation of the data reported by BV Labs suggested potential sample contamination, whereby eight dissolved metals samples had elevated concentrations compared to the total concentrations (>30%) and compared to other nearby station values (Figure B-2). It is unclear what specifically caused the discrepancy in concentrations that is evident in Figure B-2, as the laboratory facility (BV Labs, Edmonton), the analytical method (ion chromatography), and general laboratory procedures were consistent across all samples in 2020.

Dissolved metals data used in the report analyses are limited to the major ions (i.e., calcium, magnesium, potassium, and sodium). Instead of removing the dissolved ions data from the open-water dataset, figures and analyses were presented for both the total and dissolved forms. Dissolved calcium, magnesium, potassium, and sodium are used in the calculation of total dissolved solids (TDS). Therefore, the potential contamination affecting the dissolved metals during the open-water season also affected calculated TDS. Values of TDS were recalculated for the eight affected samples using the total concentrations. The elevated values did not affect the Action Level evaluation as none of the affected samples were within the NF area. One of the MF stations used in the analysis of effects from dust deposition was affected (MF3-3M); however, both the total and dissolved forms of calcium, magnesium, potassium, and sodium met the criteria for Action Level 1.

Figure B-2 Abnormal Results for Dissolved Metals in Lac de Gras, 2020



T = top depth; M = middle depth; B = bottom depth.

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ALS / BV Labs Total Ammonia Inter-Lab Comparison 2020/07/17

Prepared by: Barry Loescher, PhD, PChem, QP

Background and Plan:

Due to an observed bias between BV Labs and ALS results for total ammonia in a previous sampling round, a comprehensive comparison program was developed. This is the sixth intercomparison and third underice intercomparison.

In this program, as in the previous rounds, field personnel sampled every site in duplicate using BV Labs bottles and preservatives for samples to be submitted to BV Labs and ALS bottles and preservatives for samples to be submitted to ALS. Both labs use bottles pre-charged with sulphuric acid as preservative.

The sampling program was extensive. A total of 143 samples were received at each lab. These included 6 Trip Blanks[1], 6 Field Blanks[2], and 6 Equipment Blanks[3].

The samples for ALS were submitted to ALS Calgary and samples for BV Labs were submitted to BV Labs Calgary. All data were submitted to Dr. Barry Loescher for compilation.

Analytical Methods:

Both labs used automated chemistry analysis. There were significant differences in the methods, however, which are summarized in the following table.

Lab	*Reference*	*Instrument*	*Operating Principle*	*Colourimetry*	*Calibration*	*Comment*
BV Labs Calgary	US EPA, Method 350.1	Konelab Aquachem 250	Discrete Analyzer	Phenate	Quadratic	
ALS Calgary	J. Environ. Monit., 2005, 7, 37-42	FIA Lab	Flow Injection / Fluorescence	OPA Fluorescence	Quadratic	

---

[1] Trip Blank sample bottle containing preservative and DI water travels unopened to and from the field.

[2] Lab-supplied DI water is poured into an empty pre-preserved sample bottle in the field which is sealed and returned to the lab.

[3] Lab-supplied DI water is poured though the sampling apparatus into an empty pre-preserved sample bottle in the field which is sealed and returned to the lab.

Data Analysis:

Review of the data showed that BV Labs total ammonia data to be contaminated. The contamination was variable, with 15 results > 0.1 mg/L, not correlated to any site. Of note, 4 of 5 trip blanks and 1 equipment blank were non detect. Since, in the lab, trip blanks are treated identically to the samples, this would suggest the contamination was not introduced during the analysis process. At this time, we do not know the source of the contamination. The vials containing preservative were extensively proofed (12 vials / lot) prior to use. Additional studies are currently in progress.

In order to gain further insight, the BV Labs dissolved ammonia data was reviewed. The dissolved ammonia samples are obtained at the same time and in the same manner as the total ammonia. The only difference is that the dissolved ammonia (D) samples are added to vials not containing preservative. Upon arrival at the lab, the samples are promptly filtered and preserved. The analytical method for both D and Total (T) samples is identical.

For a number of reasons, BV Labs believes that D ≈T.

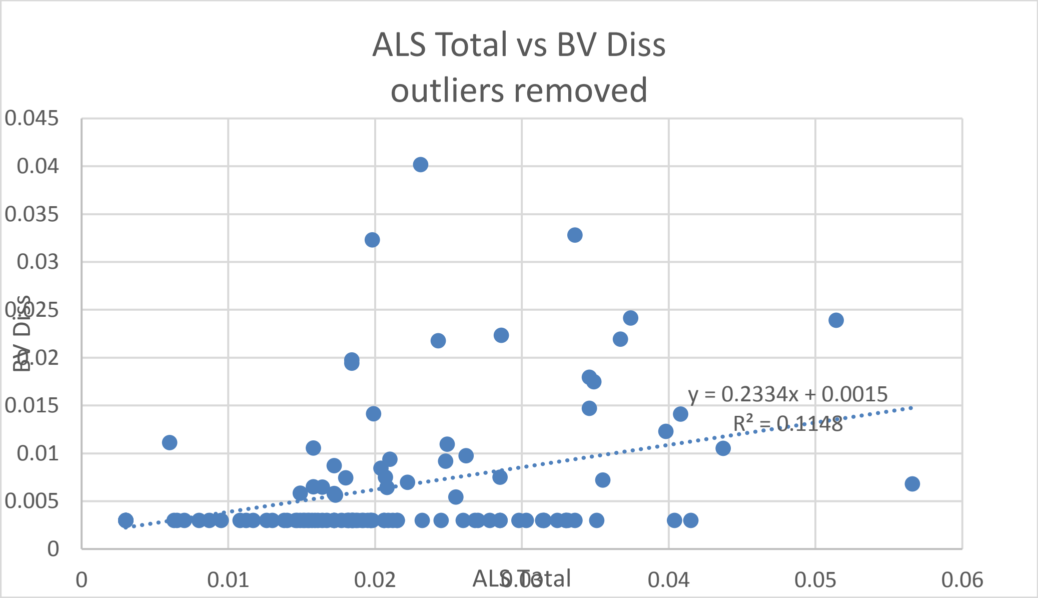
- Ammonia salts are all very soluble
- Turbidity of all the AEMP samples was < 1 NTU, 58 of 70 TSS measurements were non detect at 1 mg/L and 68 were < 2x RDL. In short there was negligible TSS
- All samples were in the range of pH 5 – 7, at which 99.9% of the ammonia is in the form of the ammonium ion, NH_4^+ which is not volatile and Heterotrophic Plate Count measurements showed no biological activity such that no losses of ammonia would be expected between sampling and preservation at the lab.

Because the BV Labs T samples were obviously contaminated, the following discussion relates to the comparison of BV Labs D samples to ALS T.

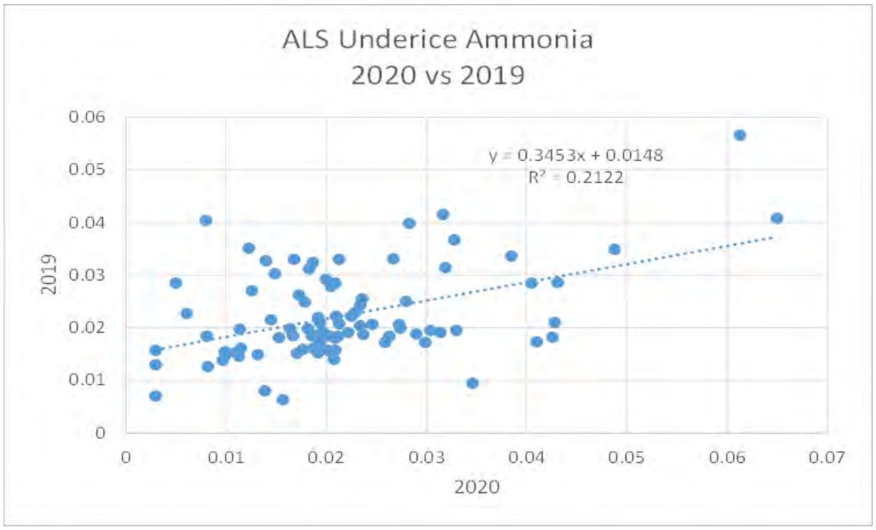
Comparing the ALS T data to the BV Labs D data. Note that not all T samples were sampled for D ammonia

Ammonia mg/L	BV Labs T	ALS T	BV Labs D
n	142	143	127
# Field QC	17	17	10
# Field QC < 0.005	5	11	10
Samples < 0.005 (not inc. QC) mg/L	0	0	67
Average Result (not inc. QC) mg/L	.069	0.022	0.013

- A t-test on the full data set showed no significant bias (P=0.95). However, when the BV Labs outliers discussed below were removed the ALS data was significantly higher than BV Labs
- Of the 127 result pairs, ALS was higher in 104, BV higher in 17 and 6 pairs were the same (both results < 0.005). 69 had differences < 0.015 mg/L, BV Labs was higher (> 0.015 mg/L) in 13 and ALS was higher in 56.
- Of note, for the 67 samples (exc. QC) where BV lab results that were < 0.005 the ALS results averaged 0.020 ± 0.009 mg/L suggesting a relatively consistent ammonia background.



- A plot of the BV vs ALS data (above) showed negligible correlation, indicative of random contamination
- The ALS data was comparable to the 2019 study with an average result of 0.021 mg/L as compared to 0.022 mg/L in 2019. There was, however, as shown in the plot below, little correlation between the data sets again suggesting random, low level contamination



- The BV Labs D data did contain 10 anomalously high results (as defined by the BV Labs D results being more than 0.020 mg/L higher than the ALS result). They are tabulated below. The data from these samples is suspect and should be viewed with caution.

Sample	BV D result	BV D - ALS T
NF4M-4-5	0.090	0.077
NF4B-5	0.077	0.061
NF2M-5	0.122	0.088
MF3-5T-4	0.064	0.049
MF3-4B-5	0.057	0.035
MF3-1T-4	0.054	0.035
MF3-1T-5	0.042	0.023
MF1-5T-4	0.062	0.046
MF1-3B-5	0.094	0.079
FF2-5T-5	0.111	0.088

These samples were repeated immediately from the original unpreserved container and confirmed. Five of these were repeated 30 days later, and although there was variability (3 increased, 2 decreased), there was no bias. Similarly, there was no bias between filtered and unfiltered.

- This tells us:
- Ammonia is stable for significantly more than 5 days in these samples
- Filtration is not introducing contamination or removing ammonia
- The contamination is occurring either in the field or during the initial lab subsampling

All data, calculations and sample information are in the attached spreadsheet. Differences are shown colour coded in Column O. The spreadsheet has been left unprotected to allow for sorting.

- The data are "noisy", particularly in the < 0.005 mg/L to 0.010 mg/L range. This is to be expected, particularly when the data are at the lower limit of instrument sensitivity.

- Trip, Field and Equipment Blanks are identified and colour coded at the top of the spreadsheet. This is the first study where there were no hits on trip blanks

	BV		ALS	
	# of Hits	**Mean Hit mg/L**	**# of Hits**	**Mean Hit mg/L**
TB	0 of 5		0 of 5	
FB	0 of 6		4 of 6	0.020
EB	0 of 6		2of 6	0.021

- In order to see if there was a correlation of hits with distance from source, the frequency of hits was tabulated, knowing the NF samples were closest to the effluent source. The table below excludes QC

	n	Average mg/L		< 0.005 mg/L	
		BV	**ALS**	**BV**	**ALS**
FF	16	0.016	0.024	8	0
MF	76	0.013	0.020	44	0
NF	32	0.017	0.028	13	0

- There was no overall correlation although the BV data did show a lower percentage of <0.005 results

- Field Duplicates: 62 ALS and 49 BV field duplicates (outliers removed) were evaluated, identified with -4 and -5 endings to the sample name. 41 of 49 BV duplicates passed criteria while 52 of 62 ALS duplicates met criteria. Even using the more stringent lab criteria performance was good. Of note, the ALS performance was much improved as compared to 2019.

Duplicates		**BV 2020**	**BV 2019 open water**	**ALS 2020**	**ALS 2019 open water**
Field Criteria	# Pass	41	43	52	20
	Total	49	46	62	46
Lab Criteria	# Pass	40	41	43	18
	Total	49	46	62	46

Conclusions / Recommendations:

- Neither data set is perfect. As discussed above, the ALS data is subject to low level contamination resulting in a high bias, however, the data set is complete, internally consistent and comparable to the 2018 under ice study. The BV Labs D data, although in the main we believe to be more accurate, has some missing data points and 10 high outliers.
- All evidence suggests that ammonia from some source other than the lake water itself continues to be an issue, resulting in data biased high to what is actually in the environment and that the sulphuric acid preservative is part of the problem.
    - Gross contamination of BV Labs T samples
    - Lower level contamination of ALS T samples
    - Lower results from the unpreserved BV Labs D samples
- Thus, it is recommended that, going forward, the AEMP ammonia samples be collected in unpreserved containers and be preserved on arrival at the lab under controlled conditions. Considering the low pH, extremely low biological activity and demonstrated stability over 14 days with respect to ammonia for the AEMP samples there is negligible chance of loss over the estimated 5 or 6 days between sampling and analysis. This is the same protocol as is currently successfully used for metals. BV Labs Calgary has instituted a protocol to ensure samples are preserved or filtered / preserved within 24 hr. of receipt
- Since the AEMP samples have very low turbidity and TSS, there seems to be little value in continuing dissolved ammonia analysis, so unless it's a regulatory requirement, we'd recommend it be discontinued
- Continue with heterotrophic plate count analysis on selected samples to assess the degree of biological activity
- Because ammonia is airborne, it presents unique issues with respect to potential contamination, particularly at low levels. BV Labs continues to work to improve our sample handling techniques to minimize lab artifacts.
    - Pipetting from the sample vial into the instrument vial although more time consuming has been found to reduce random ammonia contamination.
    - Search for ammonia free gloves. The gloves currently in use when wet have been shown to leach ammonia.
    - Total segregation of low level samples

ALS / Bureau Veritas Environmental Laboratories Division Total Ammonia Inter-Lab Comparison 2021/02/16

Prepared by: Barry Loescher, PhD, PChem, QP

Background and Plan:

Due to an observed bias between Bureau Veritas Environmental Laboratories (BV) and ALS results for total ammonia in a previous sampling round, a comprehensive comparison program was developed. This is the seventh study and fourth open water intercomparison.

In this program, as in the previous rounds, field personnel sampled every site in duplicate using Bureau Veritas (BV)V Labs bottles for samples to be submitted to BV and ALS bottles and preservatives for samples to be submitted to ALS. Previously, both labs use bottles pre-charged with sulphuric acid as preservative. In a change from previous programs, due to concerns with contamination from the acid preservative, BV samples were submitted, unpreserved. On arrival at the lab, samples were promptly preserved under controlled conditions. Similarly, an aliquot of the BV dissolved ammonia samples were syringe filtered and preserved.

The sampling program was extensive. Over 120 samples were received at each lab. These included 9 Trip Blanks[1], 6 Field Blanks[2], and 6 Equipment Blanks[3].

The samples for ALS were submitted to ALS Calgary and samples for BV were submitted to BV Calgary. All data were submitted to Dr. Barry Loescher for compilation.

Analytical Methods:

Both labs used automated chemistry analysis. There were significant differences in the methods, however, which are summarized in the following table. Both methods have comparable sensitivity, accuracy and precision. Since the sample matrix is very clean, with no high concentrations of any analyte, no significant interferences are anticipated.

Because of issues with preservative contamination in previous rounds, BV samples for Total ammonia were submitted in unpreserved vials, identical to those used for dissolved ammonia. On arrival at the lab, samples were immediately delivered to the instrument lab, where preservation and filtration / preservation was conducted in a fume hood shown to be ammonia free. Samples were immediately recapped and returned to sample receiving for log in and storage at < 6C until analysis. The filtration process involved first rinsing the syringe / filter with sample then pipetting a sample aliquot into the syringe body with filter attached. The

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[1] Trip Blank sample bottle containing DI water travels unopened to and from the field.

[2] Lab-supplied DI water is poured into an empty sample bottle in the field which is sealed and returned to the lab.

[3] Lab-supplied DI water is poured though the sampling apparatus into an empty sample bottle in the field which is sealed and returned to the lab.

plunger was inserted into the syringe body and the aliquot pushed through the filter into a new vial with preservative. This process minimizes the chance of ammonia contamination or loss through volatilization. The method Blanks were taken through exactly the same process as the samples. This is best evidence that the filtering / preserving steps due not introduce contamination. Note that these values are raw instrument data. All were below the Reporting Limit (RDL) of 0.005.

	method blank
n	29
mean recovery %	-0.002
stdev %	0.004
Maximum	0.003

Instrument Method Detail

Lab	*Reference*	*Instrument*	*Operating Principle*	*Colourimetry*	*Calibration*
BV Labs Calgary	US EPA, Method 350.1	Thermo Scientific Gallery Plus	Discrete Analyzer	Phenate	Quadratic
ALS Calgary	J. Environ. Monit., 2005, 7, 37-42	FIA Lab	Flow Injection / Fluorescence	OPA Fluorescence	Quadratic

Data Analysis:

The 3 sets of data (BV Total, BV Dissolved, ALS Total were tabulated and comparisons done for each of three combinations. In order to permit statistical evaluation all values <0.005 were assigned a value of 0.003. The following parameters were evaluated

- T-tests,
- # of pairs meeting duplicate criteria
- # of 4,5 duplicate pairs for each data set meeting duplicate criteria

In addition, the Field QC was evaluated

Finally, outliers were evaluated. This was done making the following assumptions:

- Ammonia results from the Bottom Middle and Top Depth samples from each site should be similar. Results from the depth integrated samples from each site should be similar

- Results from BV Total, BV Dissolved and ALS Total Ammonia should be similar. (See below for reasons BV believes D ≈ T)

- Outliers were calculated at the 0.05 and 0.01 level using the Grubb's test
  G= (Xh – avge Xall)/ stdev. (Xall) where
  G = Grubb's statistic which is compared against tabulated values for Xall degrees of freedom
  Xh is the highest value in the data set
  Avge Xall is the average of all values in the data set
  Stdev(Xall) is the standard deviation of all values in the data set

For the following reasons, BV believes that D ≈T

- Ammonia salts are all very soluble
- Turbidity of all the AEMP samples was < 1 NTU,
- Average TSS was 1.1 mg/L, 27 were < 1 mg/L, the maximum TSS was 2.7 mg/L, and only 5 were > 2 mg/L In short there was negligible TSS in these samples
- All samples were pH < 7, at which 99.9% of the ammonia is in the form of the ammonium ion, NH_4^+ which is not volatile and Heterotrophic Plate Count measurements showed low or no biological activity such that no losses of ammonia would be expected between sampling and preservation at the lab.

All supporting data in found in the appended Excel Workbook. The "All data" tab is most pertinent but there all also the detailed comparisons of 2 x 2 comparisons of the 3 data sets plus blank and QC summaries. The Workbook was left unprotected to allow users sorting capabilities.

Observations:

Ammonia Outliers mg/L

		BV Total	BV Dissolved	ALS Total
FF2-2-4		**0.066**	0.007	0.016
FF2-5-4		0.025	0.015	0.055
MF1-5B		0.006	0.007	**0.037**
MF2-1T		0.008	0.006	**0.042**
MF3-6-4		**0.054**	<0.005	<0.005
MF3-M		**0.045**	0.009	
NF5-4		0.010	0.010	**0.041**
🟥		Outlier 0.01 probability level		
🟨		Outlier 0.05 probability level		

The BV Total and ALS Total data had outliers. For example: Both the BV T value for MF3-6-4 and the ALS value for MF2-1T are classified by the Grubb's test as being outlier (P0.01), applying the assumptions that the duplicate depth integrated samples should be similar and the discrete Top Middle and Bottom samples should be similar.

Excluding the NF2 and NF3 sites which are discussed separately, for the 20 remaining sampling sites there were 7 outliers identified, 4 ALS, 3 BV T and 0 BV D. Values < 0.005 were assigned 0.003 in order to apply the Grubb's Test

NF2 Samples:

For this site, all BVT and 4 BVD samples, including field blanks were high, while only one ALS sample was elevated. Repeat analysis confirmed the BV results. Note that all repeats were on a different day and the repeated D samples were from a different container, the general chemistry bottle. Thus the ammonia is in the containers. There was no indication of contamination at the preparation or analysis stage. The fact that significant ammonia was found in 3 separate BV containers suggests ammonia was at that site, however, it is difficult to rationalize why the ALS samples are much lower. In the previous 2020 under ice and 2019 open water studies no lab had any results < 0.005 and the lowest ALS result was 0.012. Thus, although the BV data appears anomalously high, the ALS data is low compared to historical.

		BVT	BVD	ALS	Repeats
Field Blank	NF2-2-4	0.127	0.106	<0.0050	d & t conf
Field Blank	NF2-2-5	0.073	0.021	<0.0050	d & t conf
	NF2B	0.064	0.082	0.030	d conf
Field Blank	NF2B-2	0.163	0.001	<0.0050	t conf
	NF2M	0.069	0.076	0.006	d conf
	NF2T	0.110	0.042	0.006	t conf.

NF3 Samples:

At this site 8 of 9 discrete sample results are high averaging 0.069 mg/L while the depth integrated samples averaged 0.006 mg/L. The depth integrated and discrete samples were taken in at the same location in the same boat at approximately the same time. According to Diavik staff, in a homogenous water column, the depth integrated sample should correspond to the average of the Top and Mid samples. This was the case for the previous under ice study. In this case the Top an Mid depth samples are 14 x higher than the integrated. Also, the mean result for the under ice study (BV + ALS combined) was 0.018 compared to 0.069 mg/L in this study. It is highly unlikely that gross lab contamination would occur on the same samples in both labs. All evidence suggests that there was field contamination of the NF3 discrete samples.

Sample	Repeat	BV T	BV D	ALS
NF3-4		0.008	0.003	0.009
NF3-5		0.008	0.005	0.006
NF3B	d conf	0.063	0.054	0.006
NF3M	t conf	0.130	0.033	0.097
NF3T	d conf.	0.036	0.112	0.090

Field QC:

In contrast to the previous under ice study where BV had no "hits" on the blanks and ALS none on the trip blanks, in this study only the **Equipment Blanks** were good with only 2 low level hits on 13 measurements

Field Blanks: BV had 3 T results and 1 D result> 0.050 mg/L on NF2samples. ALS was < 0.005 on those 3 but had low level hits on 2 other NF2 samples.

The same water was used for all ALS and BV field and equipment blanks. The equipment blanks are done in the Diavik lab, suggesting there may ammonia at the sampling sites

Trip blanks were the most surprising with almost all positive results. The data averages were skewed by sample NF4M-3 which had a BV T result of 0.203 and ALS 0.285 mg/L. the highest values in the entire study.

The trip blanks and lab water used for the equipment and field blanks were prepared by BV Calgary, batch proofed, and shipped on July 27. Thus were used approx. 1 month after preparation. They were stored on site in the coolers in which they were shipped until time of use.

There were 5 retained trip blanks from the batch used for this project. They were prepared and analyzed in late Dec., 5 months after preparation. All were low level positives averaging 0.012 mg/L. This is consistent with other studies where we have noted low level leaching of ammonia after 2 – 3 mo. All the project trip blanks were analyzed within 2 months of preparation so background leaching is not expected.

In any case, there is evidence of exposure of the ALS and BV trip blanks to a significant source of ammonia contamination somewhere during the transport / storage / sampling process.

Sample	Repeat	BV T	BV D	ALS
NF3-4		0.008	<0.005	0.009
NF3-5		0.008	0.005	0.006
NF3B	d conf	0.063	0.054	0.006
NF3M	t conf	0.130	0.033	0.097
NF3T	d conf.	0.036	0.112	0.090

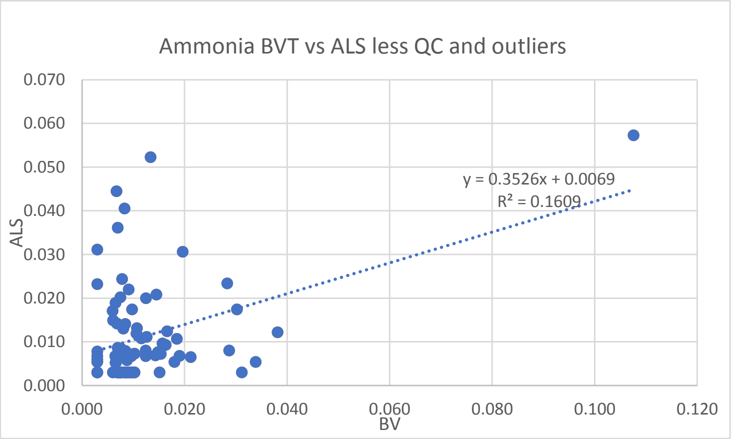
Data Set Relationships:

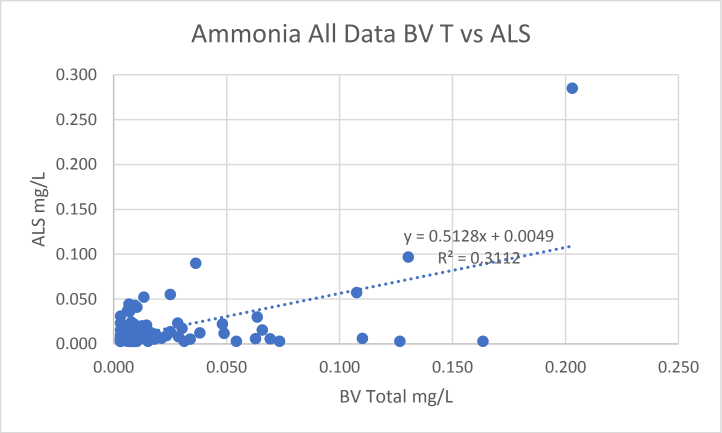
T-tests and plots were done on the three combinations of data sets. BV Total vs ALS, BV Dissolved vs ALS BV Total vs BV Dissolved. Note that for various reasons, there were some missing data points for each set. They were excluded from the comparisons. Samples < 0.005 were assigned a value of 0.003 to allow for statistical evaluation.

Comparisons were done:

- Including all data
- Excluding the Field QC
- Excluding Field QC and outliers
- Excluding Field QC, outliers NP2 and NP3 data

In every case, there was no statistical bias between the data sets at (P = 0.05) and absolutely no correlation. In the full data sets this was because of the random outliers. After removal of outliers and Field QC, the remaining low level data "noise" resulted in the very low R^2 values Two typical example plots are below.





In the "all data" tab, the differences for the three combinations are tabulated in Columns M, N & O. All differences > 0.030 are flagged by light red highlights. This table also has the Grubb's outlier calculations and indicates which samples were confirmed by repeat analysis.

Ammonia mg/L Average Values	**BV T**	**BV D**	**ALS**
all data	0.020	0.014	0.015
less QC	0.017	0.013	0.014
less NF2 NF3	0.015	0.010	0.014
less QC and outliers	0.016	0.013	0.012
less QC, outliers, NF2 NF3	0.012	0.010	0.011
all data 2020 under ice	0.062	0.013	0.021
all data 2019 Open Water	0.009		0.028

The overall average values are shown in the accompanying table. The impact of the various elements are shown by first excluding the Field, Equipment and Trip blanks, then removing the 8 identified samples containing an outlier and finally excluding all the NF2 and NF3 discrete samples.

The impact of the QC samples and outliers is significant and has been discussed previously.

The 2020 BV T under ice samples had contaminated preservative. As a result, the 2020 open water samples were collected in vials with no preservative which obviously made a significant improvement (average of 0.020 vs 0.062).

The NF2 and NF3 samples contained the majority of the anomalously high samples as can be seen from the drop in the average values (yellow highlight) as compared to the all data values.

We can find no reason for why, although not statistically significant, the BV T values are somewhat higher than the BV D and have more outliers. The sample containers are identical 40 mL vials with no preservative, both sampled at the same time. In the lab, preserving and filtering / preserving are conducted in the same location at approximately the same time. Ammonia loss during filtration is a possibility, however, our matrix spikes for this project on dissolved (filtered) samples was 104% (n=14) which indicates no losses

We were advised by Diavik that the Depth Integrated (DI) samples are exposed to the atmosphere for a somewhat longer time than the Discrete (Beta bottle samples) and as such might be higher than the Discrete samples. The opposite was the case, BV T and ALS Beta samples were on average higher. The BV D Beta and DI samples were effectively equivalent. The data suggests that airborne ammonia when sampling at site is not a significant contributor to the elevated ammonia levels/

	BVT	BVD	ALS
beta n	66	62	69
Beta ave. mg/L	0.024	0.015	0.019
Depth Int n	56	48	56
DI ave. mg/L	0.018	0.016	0.010

Conclusions / Recommendations:

- None of the data sets is perfect. As discussed above, the BV T and ALS data sets are subject to high outliers. BVT had 2 high outliers, BV D none and ALS 5. NF 2 samples were anomalously high for BV samples and significantly lower than historical for the ALS data. The poor trip blank data further complicates the analysis
- It is recommended that the identified outliers and the NF3 B M & T samples not be reported to the AEMP database or at least flagged as contaminated.
- Regardless of which data is reported to AEMP, the NF2 data is suspect is flagged as such or ideally not reported.
- Overall, with the exception of the NF2 data, the BV D data is the most consistent. However, it is understood that the Regulator would likely object to reporting of the D data. It is also understood that “cherry picking” some of each data set would not be acceptable. Because of these limitations our recommendations is to report the ALS Data. This is primarily because the high bias from the BV T NF2 samples would introduce is greater than the likely low bias from the ALS samples. If the NF2 data and outliers can be excluded, there is really nothing to choose between the two data sets.
- It is recommended that use of unpreserved vials be continued. Considering the low pH, low biological activity and demonstrated stability over 14 days with respect to ammonia for the AEMP samples there is negligible chance of loss over the estimated 5 or 6 days between sampling and preservation at the lab. This is the same protocol as is currently successfully used for metals. BV Labs Calgary protocol requires samples to be preserved or filtered / preserved within 24 hr. of receipt
- Because ammonia is airborne, it presents unique issues with respect to potential contamination, particularly at low levels. Because of the reoccurrence of hits on the BV Trip Blanks and possible storage contamination, BV will commence detailed studies of possible contamination from coolers, packing materials etc. and our protocols for preparation of trip blanks and ammonia free water.
- Studies continue on finding an ammonia free cap. We are currently testing a cap that yielded non detectable results under stringent leaching conditions and are now doing time studies.

- We are in process of obtaining ALS bottles to similarly evaluate.
- Colourimetric methods use a light source that is passed though the sample. The concentration of the analyte is proportional to the light adsorbed. It may be possible that even the very low levels of particulate in unfiltered samples are causing a physical interference by scattering some of the light beam causing a positive interference. The impact of varying levels of TSS on total and dissolved ammonia results will be evaluated.

ATTACHMENT C

INITIAL EFFLUENT AND WATER QUALITY DATA SCREENING

INITIAL EFFLUENT AND WATER QUALITY DATA SCREENING

Introduction

Data screening is the initial phase of data handling when analyzing chemistry datasets that are subject to occasional extreme values. Extreme values are frequently incorrect, reflecting field or laboratory errors, data transcription or calculation errors, or extreme natural variability. Data screening is undertaken prior to data analysis and interpretation to verify that the data quality objectives established by the *Quality Assurance Project Plan (QAPP) Version 3.1* (Golder 2017a) and the *AEMP Design Plan Version 4.1* (Golder 2017b) have been met. The purpose of data screening is to identify unusually high or low values (referred to as anomalous data), verify or correct them if possible, and make a decision whether to retain or exclude remaining anomalous data from further analysis.

The data screening approach used in this report includes a numerical method to aid in the identification of anomalous data, followed by visual/logical assessment of the identified values. This approach removes the subjectivity of classifying values based on visual evaluation of data alone. This initial screening is primarily applicable to chemistry data, because anomalous results are less common in biological (e.g., taxonomy) data and are typically resolved through contacting the taxonomist.

Methods

Initial screening of the annual AEMP datasets was completed using a method based on Chebyshev's theorem (Mann 2010) combined with the visual examination of scatterplots (Golder 2017b). The method is applied by first identifying data that lie outside the 4.47 standard deviation (SD) on a scatterplot of annual data, and then visually verifying the anomalous values based on potential spatial trends. If a datapoint was visually anomalous, it was investigated to evaluate whether it was reported in error, or if it was consistent with associated variables (e.g., total dissolved solids and major ion concentrations) and data collected in previous years. No data were identified as anomalous based on visual evaluation alone.

In cases where numerical screening identified an elevated value in the NF area or at the mixing zone boundary as anomalous, the identified value was conservatively retained in the dataset used for analysis if the SD distance from the mean was less than two times the 4.47 SD criterion discussed above. Hence, only very extreme values, which were greater than approximately 9 SD from the mean, were removed from further analysis of NF area data, upon visual confirmation of screening results. Finally, in cases where the annual datasets contained a large proportion of non-detect data (i.e., censored values), only values that were greater than or equal to five times the detection limit were considered anomalous and were removed from the analysis if visual screening confirmed the numerical screening results.

Results

Results of the initial data screening are summarized herein for effluent, mixing zone and AEMP datasets (Tables C-1 to C-3; Figures C-1 to C-13). Results consist of a table of anomalous values removed from each dataset and scatterplots, which allow visual review of anomalous data and provide transparency. Overall, the number of anomalous values identified by the data screening procedure was very small compared to the amount of data summarized, accounting for less than 0.5% of the dataset.

SNP

Table C-1 List of Anomalous Values Removed from SNP Analyses, SNP 1645-18 and 1645-18B (Effluent)

Variable	Station	Value	Unit	Date	Standard Deviation Distance [(a)]
Total Cobalt	1645-18	1.15	µg/L	11-Aug-2020	5.58
Total Copper	1645-18	1.61	µg/L	12-Jul-2020	5.77
Soluble Reactive Phosphorus	1645-18	48	µg-P/L	23-Aug-2020	4.71
Total Dissolved Phosphorus	1645-18	40.4	µg-P/L	31-May-2020	4.58
Total Zinc	1645-18	2.87	µg/L	13-Feb-2020	5.15
Total Zirconium	1645-18	0.489	µg/L	26-Oct-2020	7.57
Acidity (pH 8.3)	1645-18B	18.5	mg/L	18-Jul-2020	7.31
Total Cobalt	1645-18B	1.22	µg/L	11-Aug-2020	5.77
Total Lead	1645-18B	0.0511	µg/L	12-Jul-2020	5.66
Total Nickel	1645-18B	18.2	µg/L	11-Aug-2020	4.57
Total Thallium	1645-18B	0.0323	µg/L	06-Jul-2020	4.87
Total Tin	1645-18B	0.096	µg/L	18-Jul-2020	6.04
Total Zinc	1645-18B	6.92	µg/L	29-Aug-2020	7.31
Total Zirconium	1645-18B	0.494	µg/L	26-Oct-2020	7.57

a) Number of standard deviations from the mean calculated for the 2020 monitoring period.

µg/L = micrograms per litre; µg-P/L= micrograms phosphorus per litre.

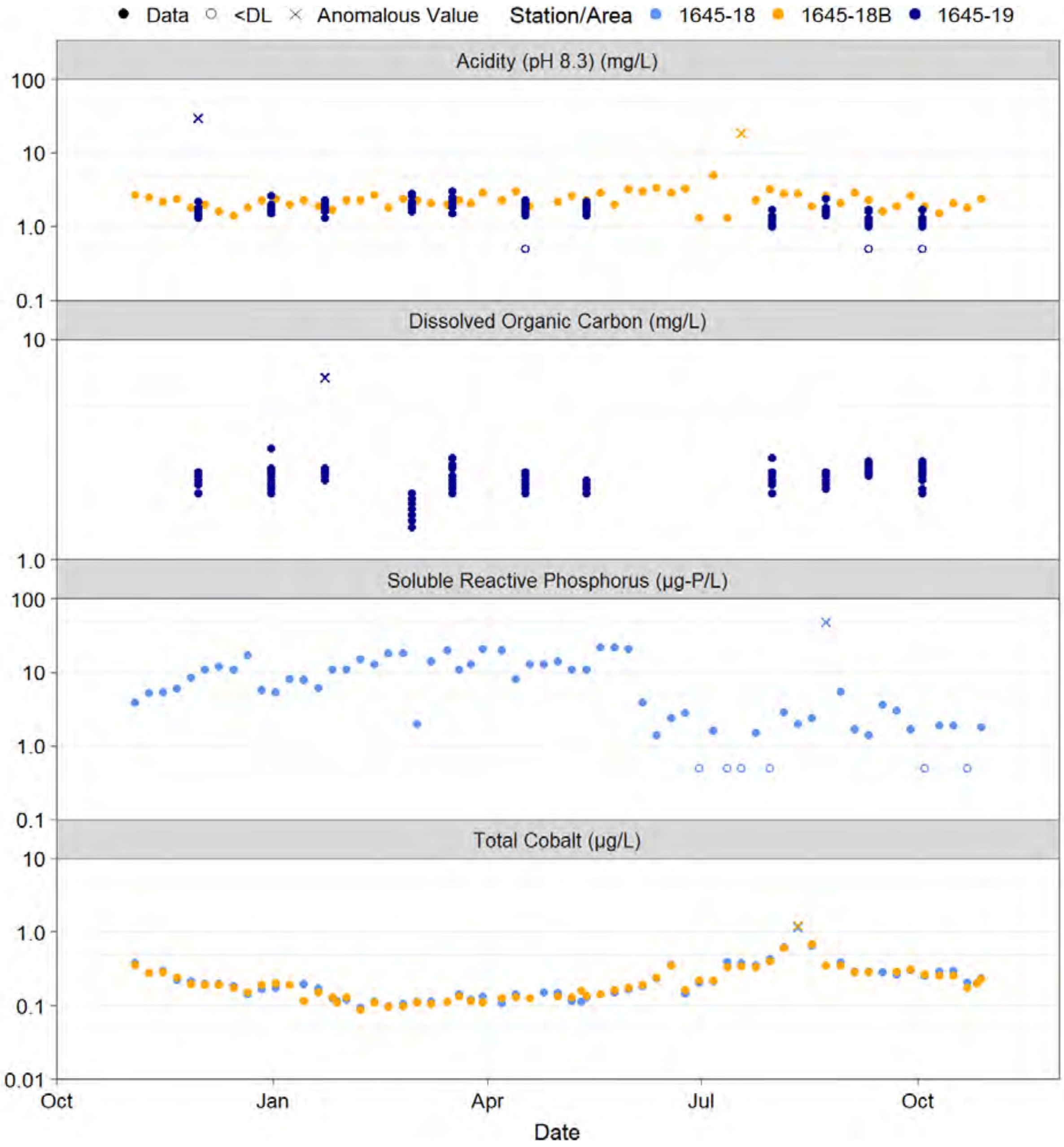
Table C-2 List of Anomalous Values Removed from SNP Analyses, SNP 1645-19A, 1645-19B and 1645-19C (Mixing Zone)

Variable	Station	Value	Unit	Date	Standard Deviation Distance [(a)]
Acidity (pH 8.3)	1645-19	29.8	mg/L	30-Nov-2019	11.88
Dissolved Organic Carbon	1645-19	6.7	mg/L	23-Jan-2020	9.37
Total Suspended Solids	1645-19	8.7	mg/L	13-May-2020	9.17
Total Copper	1645-19	3.11	µg/L	29-Feb-2020	11.63
Total Lead	1645-19	0.0594	µg/L	30-Nov-2019	10.67
Total Tin	1645-19	0.184	µg/L	31-Jul-2020	11.28
Total Zinc	1645-19	9.03	µg/L	23-Aug-2020	9.67

a) Number of standard deviations from the mean calculated for the 2020 monitoring period.

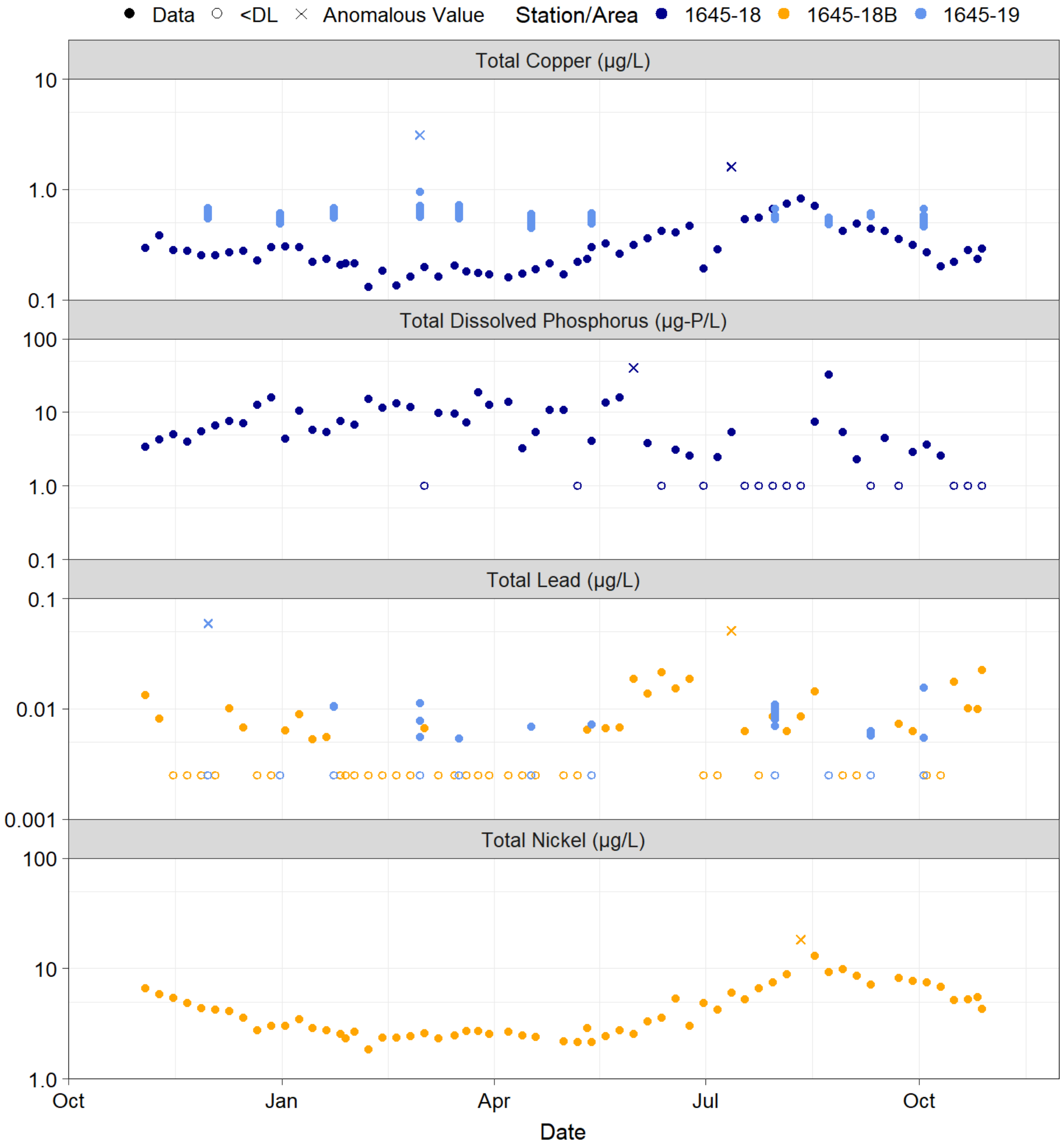
µg/L = micrograms per litre; µg-P/L= micrograms phosphorus per litre.

Figure C-1 Anomalous Data Removed from SNP Analyses Completed for Acidity (pH 8.3), Dissolved Organic Carbon, Soluble Reactive Phosphorus, and Total Cobalt



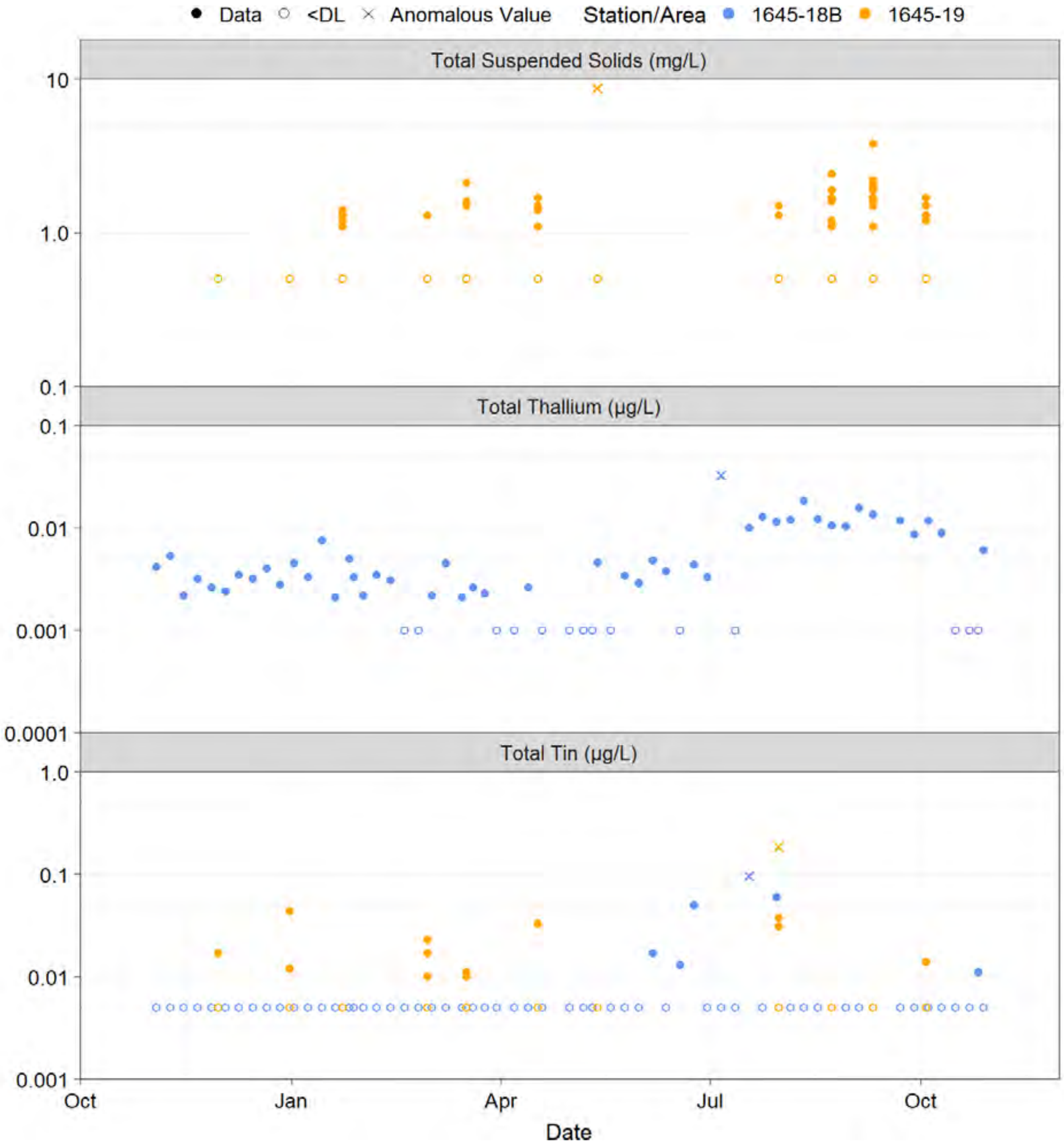
µg/L = micrograms per litre; µg-P/L = micrograms phosphorus per litre; DL= detection limit.

Figure C-2 **Anomalous Data Removed from SNP Analyses Completed for Total Copper, Total Dissolved Phosphorus, Total Lead, and Total Nickel**



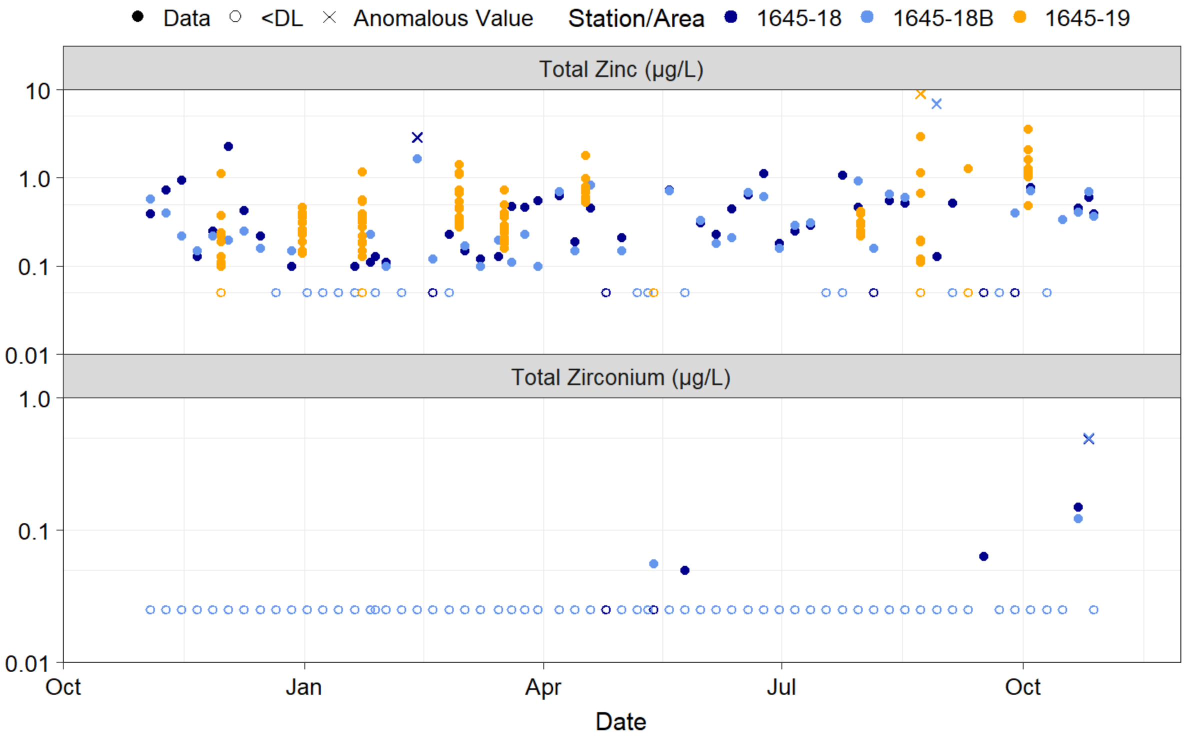
µg/L = micrograms per litre; µg-P/L = micrograms phosphorus per litre; DL= detection limit.

Figure C-3 **Anomalous Data Removed from SNP Analyses Completed for Total Suspended Solids, Total Thallium, and Total Tin**



µg/L = micrograms per litre; DL= detection limit.

Figure C-4 Anomalous Data Removed from SNP Analyses Completed for Total Zinc and Total Zirconium



µg/L = micrograms per litre; DL= detection limit.

AEMP

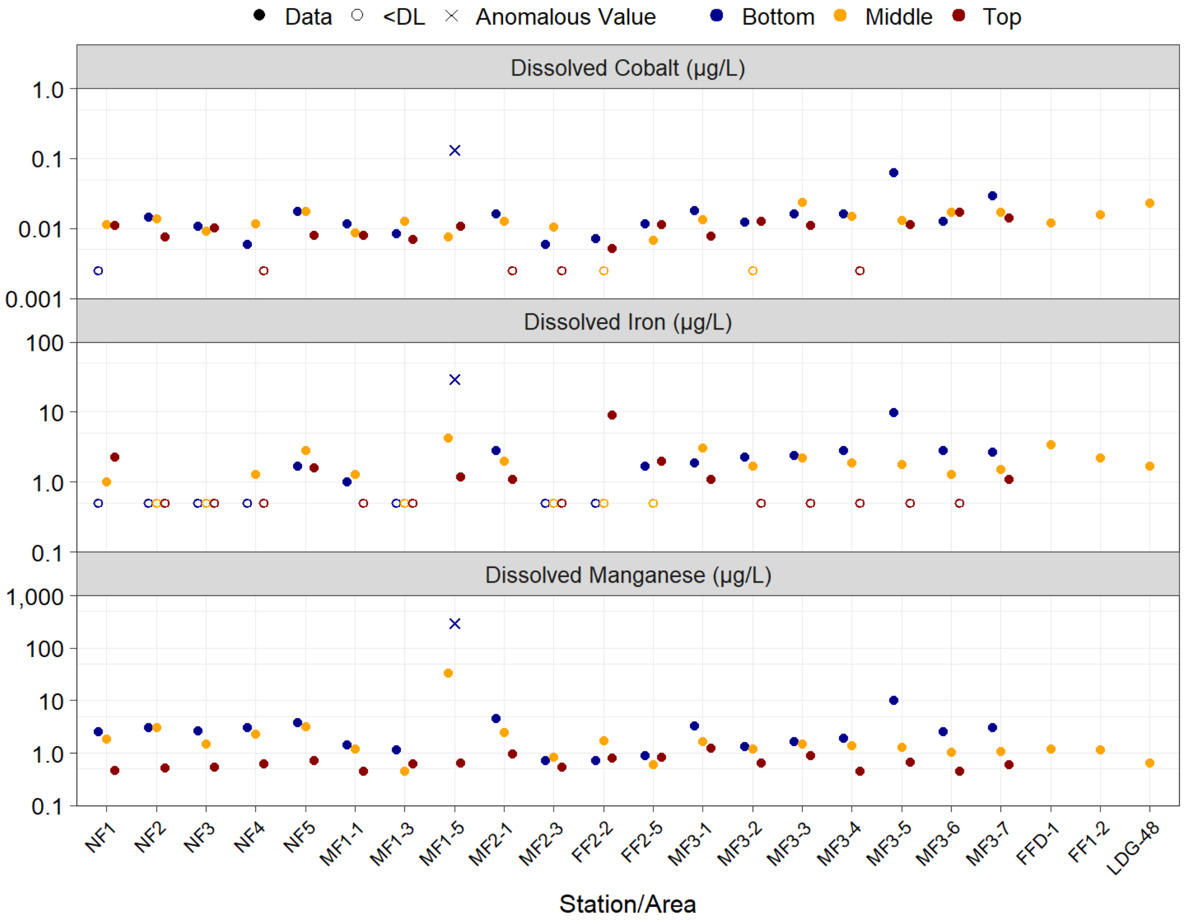
Table C-3 List of Anomalous Values Removed from AEMP Analyses

Variable	Station	Season	Value	Unit	Date	Standard Deviation Distance [(a)]
Dissolved Cobalt	MF1-5B	IC	0.131	µg/L	22-Apr-2020	6.64
Dissolved Iron	MF1-5B	IC	28.9	µg/L	22-Apr-2020	6.83
Dissolved Manganese	MF1-5B	IC	289	µg/L	22-Apr-2020	7.56
Total Antimony	MF3-4T	IC	0.16	µg/L	26-Apr-2020	5.30
Total Bismuth	MF1-5B	IC	0.0431	µg/L	22-Apr-2020	7.62
Total Cobalt	MF3-5B	IC	0.102	µg/L	26-Apr-2020	6.06
Total Copper	MF3-5T	IC	0.05	µg/L	26-Apr-2020	4.83
Total Iron	MF3-5B	IC	18.3	µg/L	26-Apr-2020	4.70
Total Iron	MF1-5B	IC	18.9	µg/L	22-Apr-2020	4.88
Total Magnesium	MF3-5T	IC	0.01	mg/L	26-Apr-2020	4.56
Total Manganese	MF1-5B	IC	182	µg/L	22-Apr-2020	7.32
Total Potassium	MF3-5T	IC	0.01	mg/L	26-Apr-2020	5.07
Total Thallium	FF1-2	IC	0.0126	µg/L	22-Apr-2020	5.52
Total Zinc	MF3-3M	IC	3.27	µg/L	25-Apr-2020	4.93
Dissolved Boron	FFD-1	OW	18.7	µg/L	18-Aug-2020	4.72
Dissolved Calcium	FF2-2B	OW	10.1	mg/L	19-Aug-2020	6.92
Dissolved Chromium	MF2-1T	OW	0.225	µg/L	28-Aug-2020	4.79
Dissolved Hardness	FF2-2B	OW	30.8	mg/L	19-Aug-2020	5.94
Dissolved Thallium	MF3-7B	OW	0.0331	µg/L	21-Aug-2020	7.31
Dissolved Zinc	MF1-5M	OW	16.1	µg/L	31-Aug-2020	4.61
Fluoride	MF2-3B	OW	0.038	mg/L	28-Aug-2020	4.63
Total Cobalt	FF2-5T	OW	0.288	µg/L	19-Aug-2020	5.59
Total Dissolved Phosphorus	FFD-1M	OW	151	µg-P/L	18-Aug-2020	6.96
Total Lead	MF3-7T	OW	0.0419	µg/L	21-Aug-2020	6.99
Total Thallium	MF2-3B	OW	0.0061	µg/L	28-Aug-2020	5.08
Total Zinc	MF2-1B	OW	29	µg/L	28-Aug-2020	4.47

a) Number of standard deviations from the mean calculated for the 2020 monitoring period.

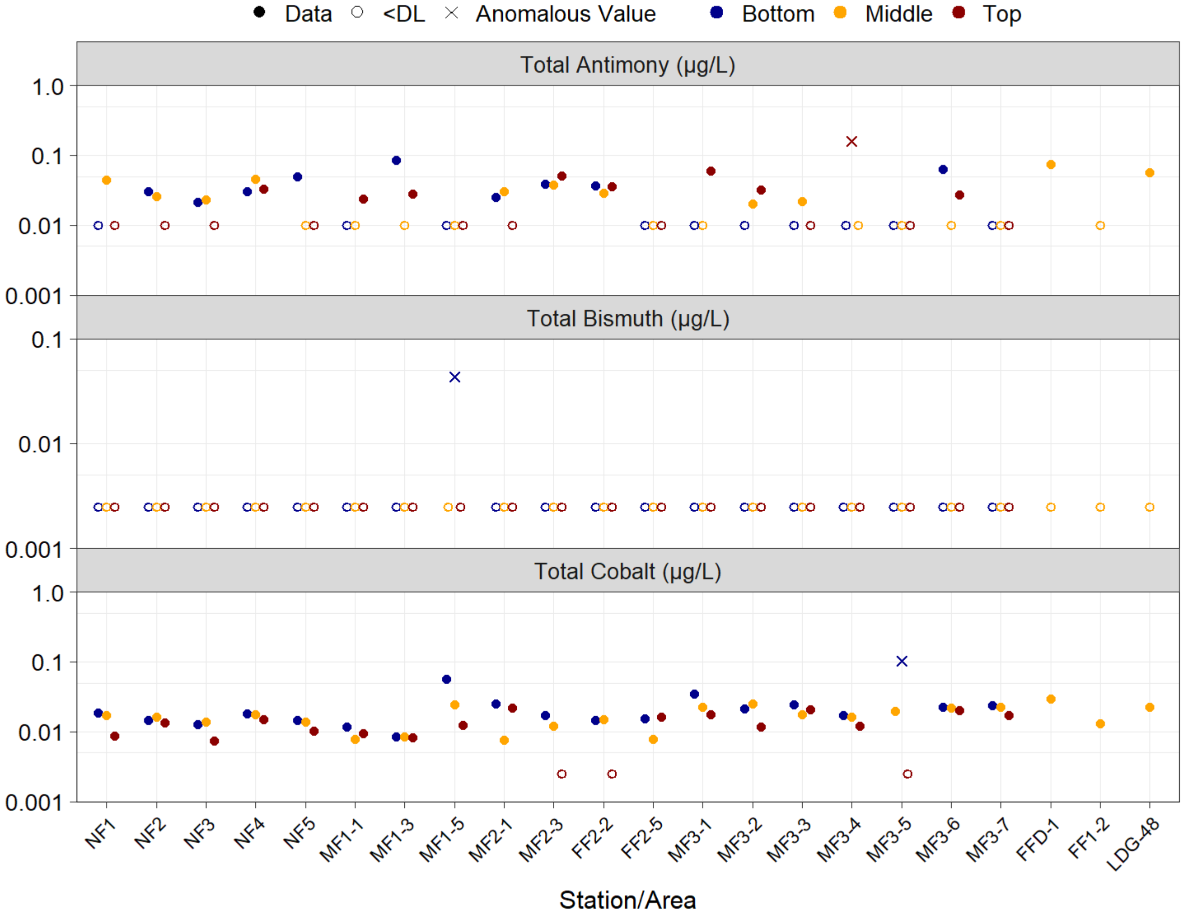
µg/L = micrograms per litre; µg-P/L = micrograms phosphorus per litre; IC = ice-cover; OW = open-water; T = top depth; M = middle depth; B = bottom depth; MF = mid-field; FF = far-field; LDG = Lac De Gras.

Figure C-5 **Anomalous Data Removed from AEMP Analyses Completed for Dissolved Cobalt, Dissolved Iron, and Dissolved Manganese, Ice-Cover Season, 2020**



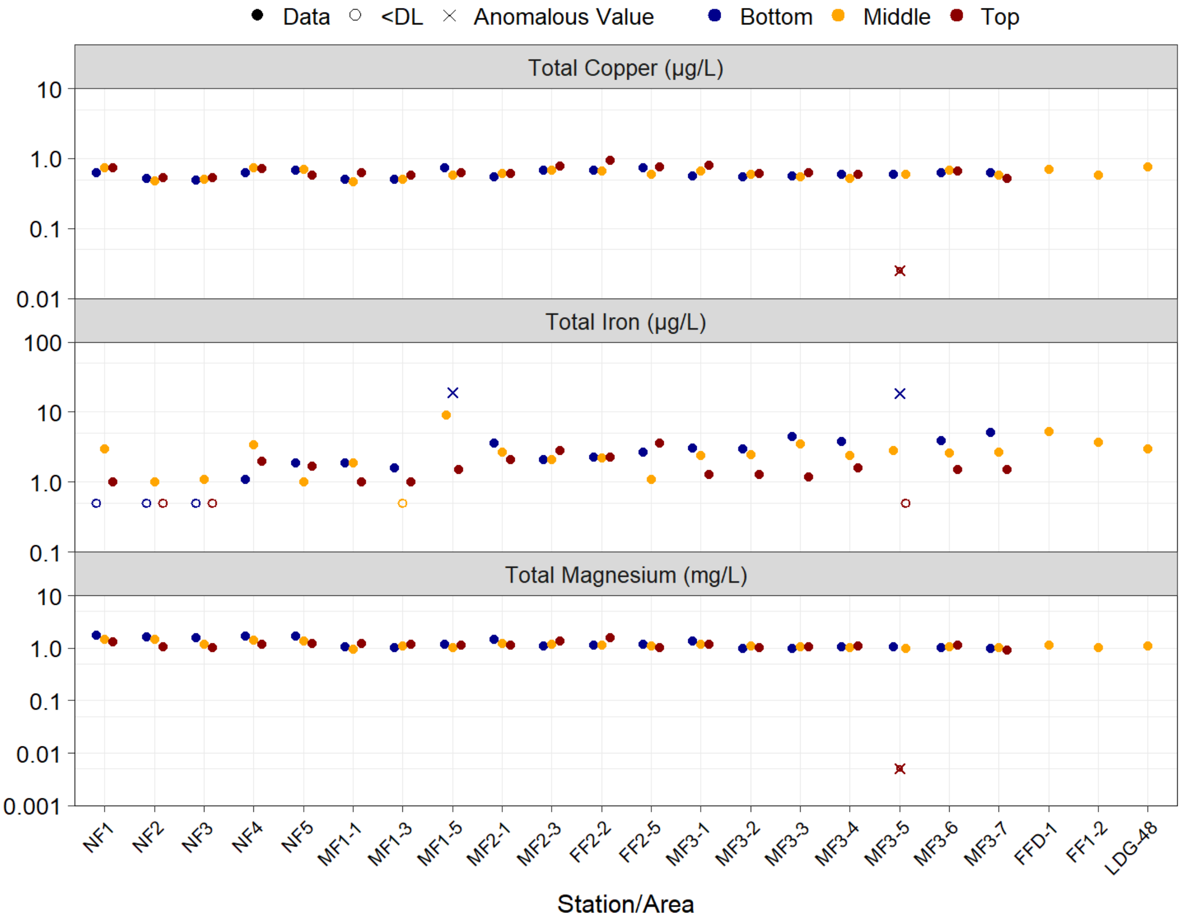
µg/L = micrograms per litre; DL= detection limit.

Figure C-6 **Anomalous Data Removed from AEMP Analyses Completed for Total Antimony, Total Bismuth, and Total Cobalt, Ice-Cover Season, 2020**



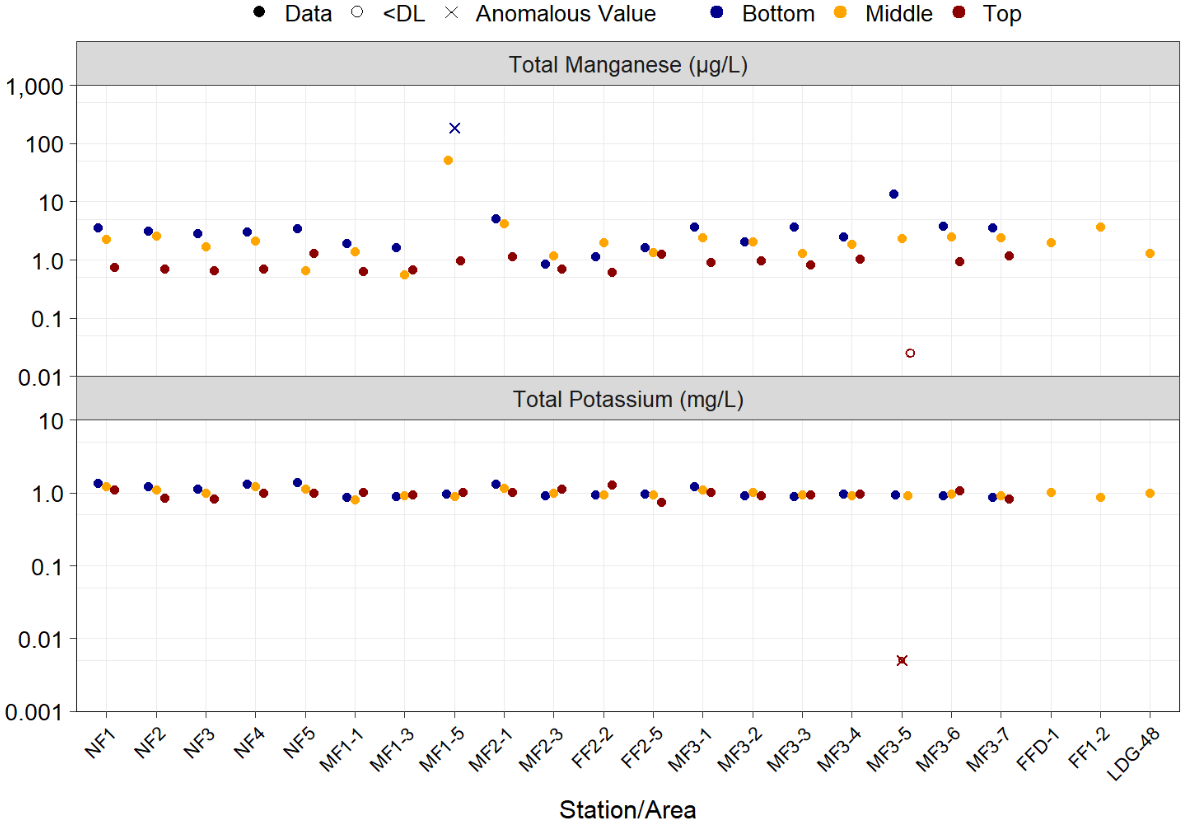
µg/L = micrograms per litre; DL= detection limit.

Figure C-7 **Anomalous Data Removed from AEMP Analyses Completed for Total Copper, Total Iron, and Total Magnesium, Ice-Cover Season, 2020**



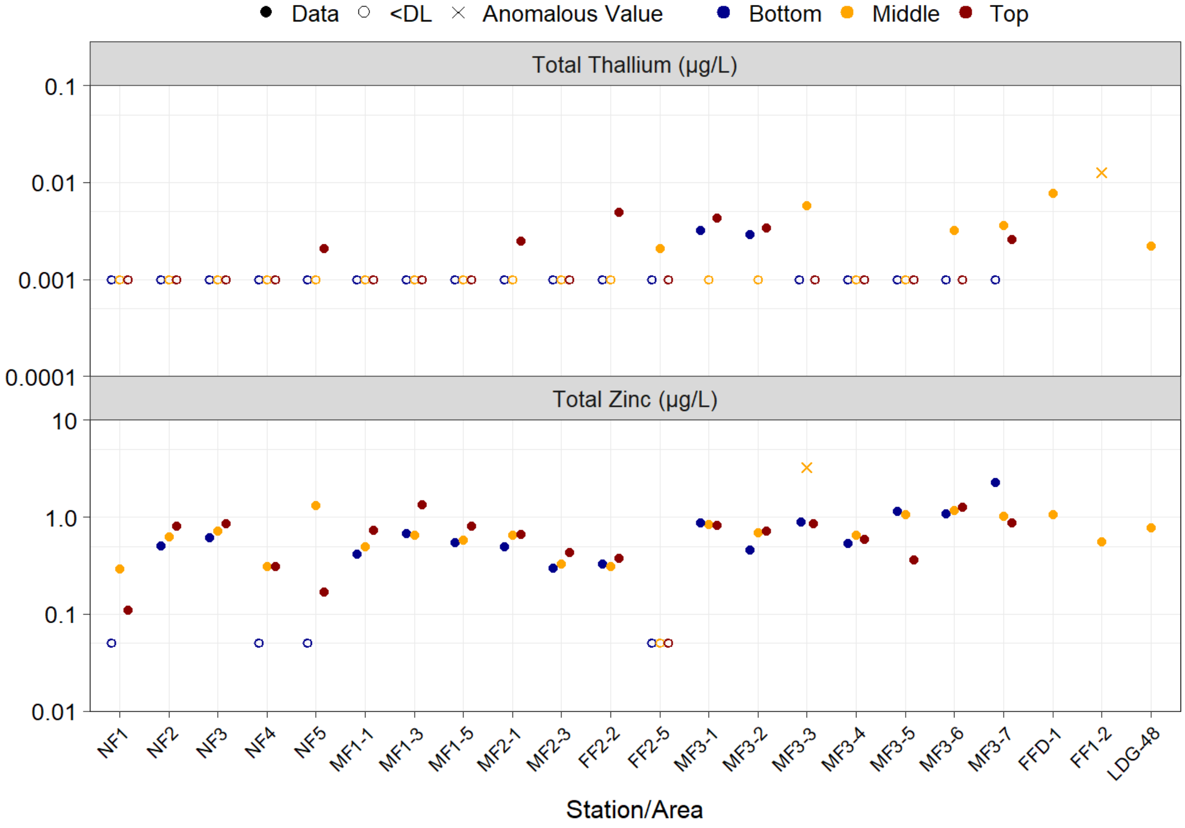
µg/L = micrograms per litre; DL= detection limit.

Figure C-8 **Anomalous Data Removed from AEMP Analyses Completed for Total Manganese and Total Potassium, Ice-Cover Season, 2020**



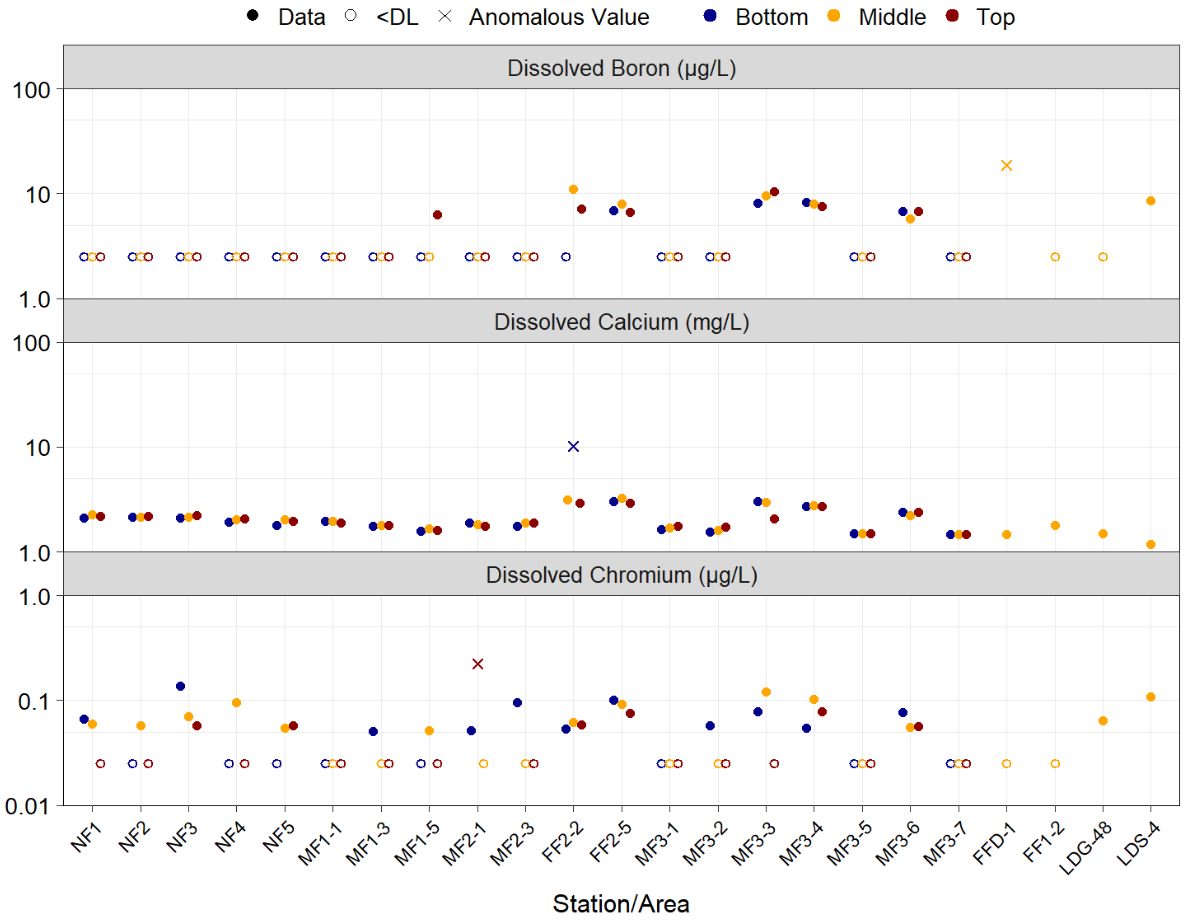
µg/L = micrograms per litre; DL= detection limit.

Figure C-9 **Anomalous Data Removed from AEMP Analyses Completed for Total Thallium and Total Zinc, Ice-Cover Season, 2020**



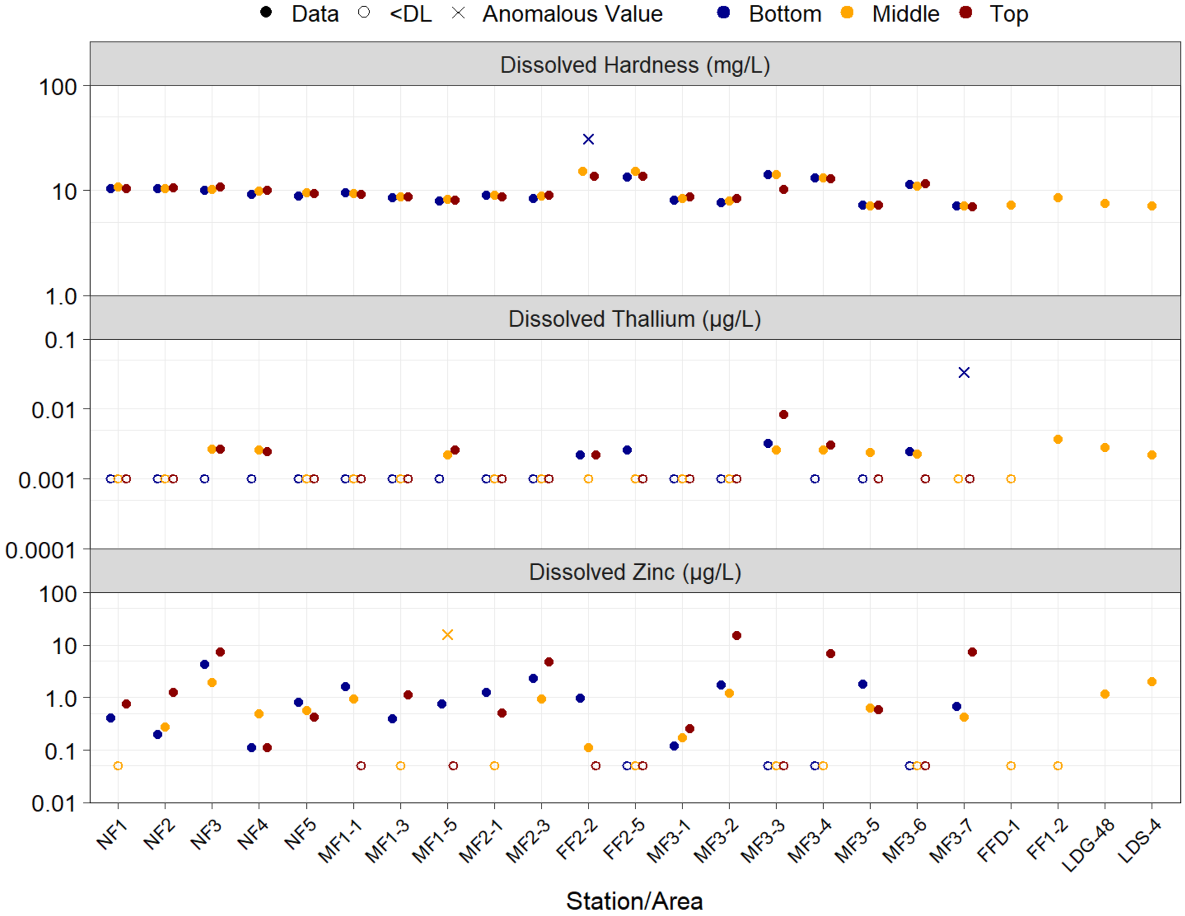
µg/L = micrograms per litre; DL= detection limit.

Figure C-10 Anomalous Data Removed from AEMP Analyses Completed for Dissolved Boron, Dissolved Calcium, and Dissolved Chromium, Open-Water Season, 2020



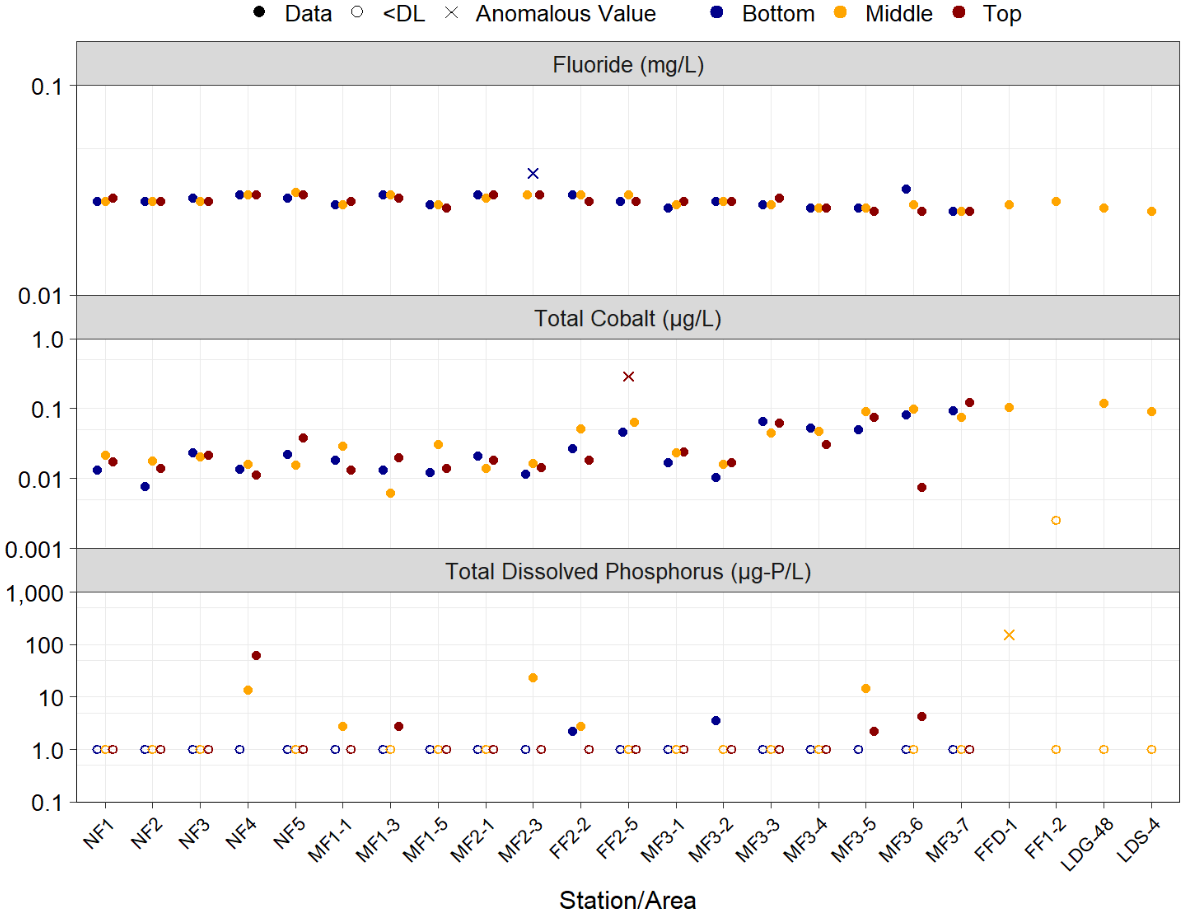
µg/L = micrograms per litre; DL= detection limit.

Figure C-11 **Anomalous Data Removed from AEMP Analyses Completed for Dissolved Hardness, Dissolved Thallium, Dissolved Zinc, Open-Water Season, 2020**



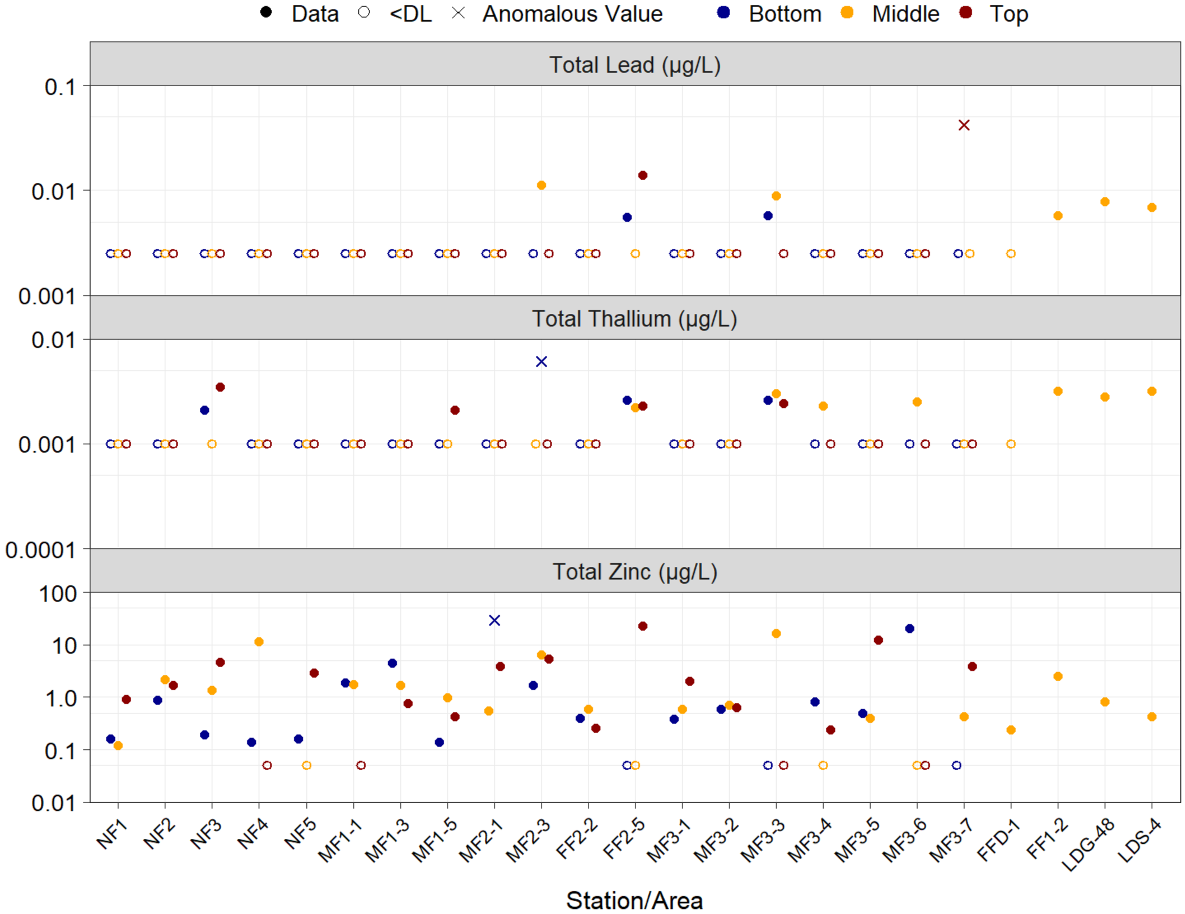
µg/L = micrograms per litre; DL= detection limit.

Figure C-12 **Anomalous Data Removed from AEMP Analyses Completed for Fluoride, Total Cobalt, and Total Dissolved Phosphorus, Open-Water Season, 2020**



µg/L = micrograms per litre; µg-P/L = micrograms phosphorus per litre; DL= detection limit.

Figure C-13 Anomalous Data Removed from AEMP Analyses Completed for Total Lead, Total Thallium, and Total Zinc, Open-Water Season, 2020



µg/L = micrograms per litre; DL= detection limit.

References

Golder (Golder Associates Ltd.). 2017a. Diavik Diamond Mine - Aquatic Effects Monitoring Program – Quality Assurance Project Plan (QAPP). Version 3.1. Prepared for Diavik Diamond Mines (2012) Inc., Yellowknife, NT. June 2017.

Golder. 2017b. Diavik Diamond Mine Inc. – Aquatic Effects Monitoring Program Design Plan Version 4.1. Prepared for Diavik Diamond Mines (2012) Inc. Yellowknife, NT, Canada. June 2017.

Mann PS. 2010. Introductory Statistics. 7th Edition. John Wiley and Sons, Inc. Hoboken, NJ.

ATTACHMENT D

2020 WATER QUALITY RAW DATA – AEMP AND SNP (SNP 1645-18/18B AND SNP 1645-19)

These data are provided electronically as an Excel file.

ATTACHMENT E

2020 TOXICITY TESTING RAW DATA

These data are provided electronically as an Excel file.

APPENDIX III

SEDIMENT REPORT

No information was available for this appendix in 2020; this component is only completed during comprehensive years.

APPENDIX IV

BENTHIC INVERTEBRATE REPORT

No information was available for this appendix in 2020; this component is only completed during comprehensive years.

APPENDIX V

FISH REPORT

No information was available for this appendix in 2020; this component is only completed during comprehensive years.

APPENDIX VI

PLUME DELINEATION SURVEY

No information was available for this appendix in 2020 as no plume delineation survey was completed.

APPENDIX VII

DIKE MONITORING STUDY

No information was available for this appendix in 2020 as no dike monitoring study was completed.

APPENDIX VIII

FISH SALVAGE PROGRAM

No information was available for this appendix in 2020 as no fish salvage program was completed.

APPENDIX IX

FISH HABITAT COMPENSATION MONITORING

No information was available for this appendix in 2020 as no fish habitat compensation monitoring was completed.

APPENDIX X

FISH PALATABILITY, FISH HEALTH, AND FISH TISSUE CHEMISTRY SURVEY

No information was available for this appendix in 2020 as no Fisheries Authorization surveys were completed.

APPENDIX XI

PLANKTON REPORT

PLANKTON REPORT IN SUPPORT OF THE 2020 AEMP ANNUAL REPORT FOR THE DIAVIK DIAMOND MINE, NORTHWEST TERRITORIES

Submitted to:

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DISTRIBUTION

1 Copy –	Diavik Diamond Mines (2012) Inc., Yellowknife, NT
1 Copy –	Golder Associates Ltd., Calgary, AB
1 Copy –	Wek'èezhìı Land and Water Board

March 2021
20136424/10000

Doc No. RPT-2041 Ver. 0
PO No. 3104360642

DDMI acknowledges that unsecured electronic media is susceptible to unauthorized modification, deterioration, and incompatibility and therefore DDMI cannot rely upon the unsecured electronic media versions of this Report. In the event of any discrepancy, Golder's native, secured file shall govern.

Executive Summary

In 2020, Diavik Diamond Mines (2012) Inc. (DDMI) completed the field component of an Aquatic Effects Monitoring Program (AEMP) in Lac de Gras, Northwest Territories, as required by Water Licence W2015L2-0001 (WLWB 2015) and according to the *AEMP Design Plan Version 4.1*, approved by the Wek'èezhìı Land and Water Board. This report presents the results of the 2020 plankton sampling program. Objectives of the plankton program were to monitor for potential ecological effects in phytoplankton and zooplankton community endpoints (i.e., abundance, biomass, and taxonomic composition) and assess the plankton community as indicators of potential toxicological effects from the Mine water discharge and other stressors from the Mine.

Plankton samples were collected and analyzed from twenty-three stations in Lac de Gras during the open-water season in 2020. Overall, the plankton community data suggest that a Mine-related nutrient enrichment effect is occurring in Lac de Gras. The plankton community data do not indicate toxicological impairment. The 2020 phytoplankton results are consistent with a nutrient enrichment effect, showing an increase in total phytoplankton biomass in the near-field (NF) area. The zooplankton data suggest that changes are occurring in the NF area of Lac de Gras. Zooplankton biomass in the NF area was generally higher relative to the MF2 and MF3 areas, and was above the reference condition mean.

Action Levels for toxicological impairment were not triggered and results are consistent with nutrient enrichment, as demonstrated by higher plankton biomass in the NF area compared to the MF areas.

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Acronyms and Abbreviations

AEMP	Aquatic Effects Monitoring Program
AIC	Akaike’s information criterion
AICc	Akaike’s information criterion corrected for small sample size
Biologica	Biologica Environmental Services, Ltd.
DDMI	Diavik Diamond Mines (2012) Inc.
e.g.	for example
et al.	and more than one additional author
Eco-Logic	Eco-Logic Ltd.
FF	far-field
Golder	Golder Associates Ltd.
i.e.	that is
LDG	Lac de Gras
LDS	Lac du Sauvage
MF	mid-field
Mine	Diavik Diamond Mine
n	sample size/count
NF	near-field
P	probability
QA/QC	quality assurance/quality control
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
r^2 or R^2	coefficient of determination
RPD	relative percent difference
Salki	Salki Consultants Inc.
SD	standard deviation
SOP	standard operating procedure
sp.	species
spp.	plural of species
WLWB	Wek'èezhìı Land and Water Board

Symbols and Units of Measure

±	plus or minus
%	percent
>	greater than
<	less than
µm	micrometre
cm	centimetre
cells/L	cells per litre
ind/L	individuals per litre
km	kilometre
m	metre
mg/m^3	milligrams per cubic metre
mL	millilitre

1 INTRODUCTION

1.1 Background

Diavik Diamond Mines (2012) Inc. (DDMI) has been monitoring plankton as indicators of changes in Lac de Gras water quality since 2007 (Golder 2011, 2016, 2018, 2020a). In 2013, DDMI revised its Aquatic Effects Monitoring Program (AEMP) for the Diavik Diamond Mine (Mine), as required by Water Licence W2007L2-0003 (WLWB 2007). Among the revisions to the *AEMP Study Design Version 3.5* (Golder 2014) approved by the Wek'èezhìı Land and Water Board (WLWB) was the addition of plankton as a monitoring component. Plankton monitoring occurs annually, once during the open-water season (between 15 August and 15 September) which is consistent with other AEMP components (Golder 2017a).

In 2020, DDMI completed the field component of its AEMP, as required by Water Licence W2015L2-0001 (WLWB 2015). The assessment of the plankton data collected during the 2020 AEMP field program, which was carried out by DDMI according to the *AEMP Design Plan Version 4.1* (Golder 2017a), is presented herein.

1.2 Objectives

The objective of the plankton component of the AEMP is to monitor the potential ecological effects of the Mine on the phytoplankton and zooplankton communities in Lac de Gras, and to assess whether toxicological changes are occurring in the plankton community. Effects on the plankton communities were evaluated using gradient analysis, and visual and statistical comparisons of plankton biomass, richness, and community composition in the NF and MF areas to the reference conditions for Lac de Gras (as defined in the *AEMP Reference Conditions Report Version 1.4* [Golder 2019a]).

1.3 Scope and Approach

The plankton component of the AEMP is designed to monitor both spatial and temporal changes in phytoplankton and zooplankton biomass, richness, and community composition. As described in *AEMP Design Plan Version 4.1* (Golder 2017a), the objective of the annual report is to assess whether Mine-related toxicological changes are occurring in the plankton communities in the near-field (NF) and mid-field (MF) areas of Lac de Gras, and to evaluate whether any Action Levels have been triggered. Temporal analyses and an assessment of trends over time are completed at three-year intervals in re-evaluation reports; results of the most recent temporal trend assessment were provided in the *2017 to 2019 Aquatic Effects Re-evaluation Report* (Golder 2020b).

Effects on the plankton communities are evaluated using gradient analysis, and visual and statistical comparisons of plankton variables in the NF and MF areas to the reference condition, as defined in the *AEMP Reference Conditions Report Version 1.4* (Golder 2019a). Values that were beyond the reference condition were different from what would be considered natural variation in Lac de Gras. The importance of effects observed on plankton variables was evaluated according to the Action Level classification defined in the *AEMP Design Plan Version 4.1* (Golder 2017a).

2 METHODS

2.1 Field Sampling

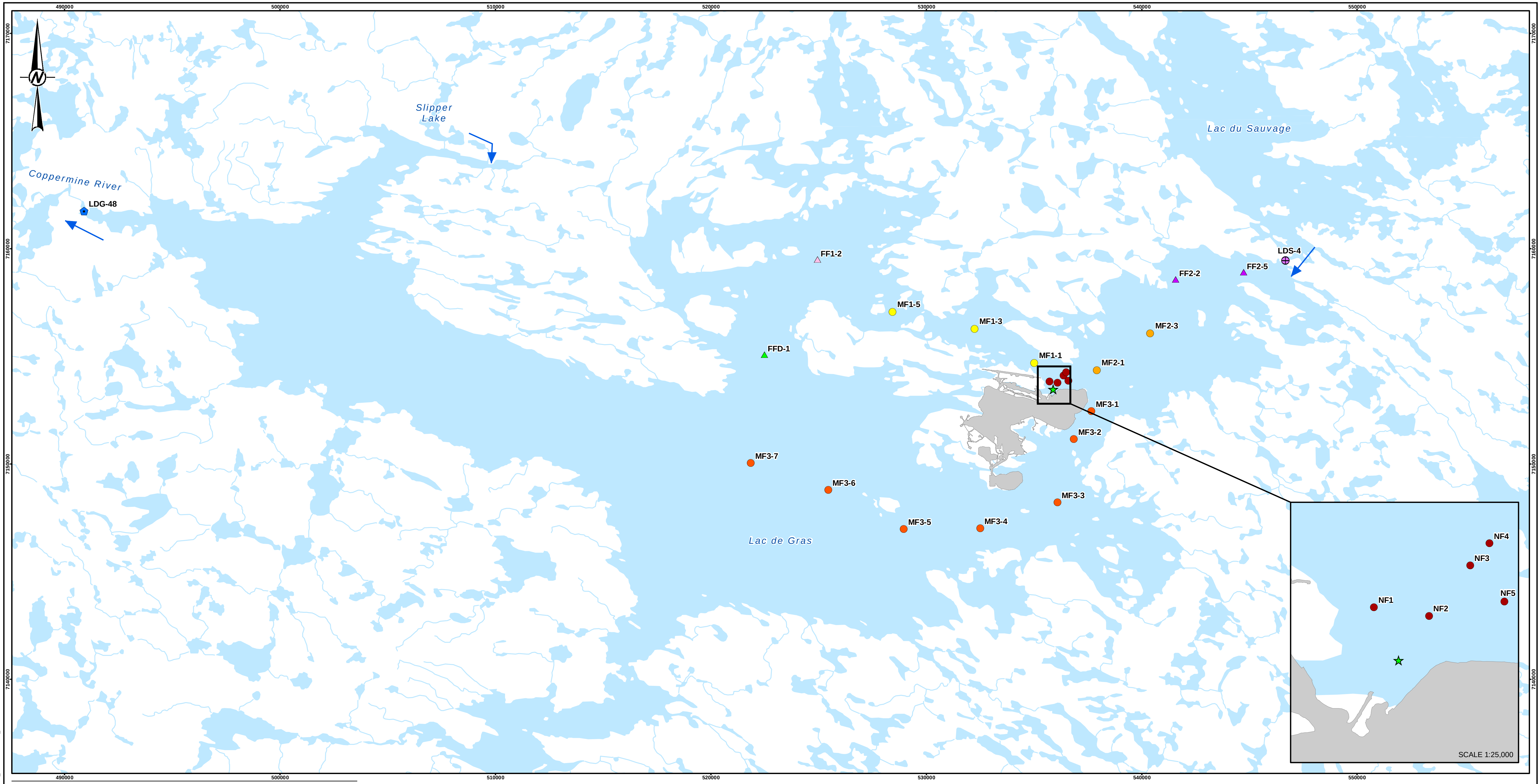
Plankton sampling was conducted by DDMI staff during the open-water season, from 18 August to 7 September 2020, in accordance with *AEMP Design Plan Version 4.1* (Golder 2017a) and the DDMI Standard Operating Procedure (SOP): ENVI-923-0119 “AEMP Combined Open Water and Ice Cover”. Water column profile measurements of field parameters and samples for water chemistry were collected concurrently as part of the *Effluent and Water Chemistry Report* (Appendix II). No deviations from the SOP were reported during sample collection.

Twenty-three stations located in eight general areas of Lac de Gras were sampled by DDMI during the 2020 AEMP (Table 2-1, Figure 2-1). Sampling areas were selected based on exposure to the Mine effluent (Golder 2017a), and consisted of the NF area, and three MF areas (i.e., MF1, MF2, and MF3). The MF1 transect runs northwest from the NF area, towards the FF1 area. The MF2 transect runs to the northeast, towards the Lac du Sauvage (LDS) inlet. The FF2 area formerly encompassed five stations and was designated and analyzed as a separate FF area; however, the two remaining stations in this area are now considered together with MF2 stations as the MF2 transect. The MF3 transect is located south of the NF area, and extends towards the FFB and FFA areas. Per the WLWB directives approving a number of updates outlined in the proposed *AEMP Design Plan Version 5.2* (Golder 2020c), Station FF1-2 was included in interim sampling years, instead of only being sampled in comprehensive years, and a newly added station, FFD-1, was added to help delineate the extent of effects extending away from the NF area. These updates were included in the 2020 monitoring program.

Sampling locations, dates, and water depths are provided in Table 2-1. Five stations were sampled in the NF area, three stations were sampled in the MF1 area, four stations were sampled in the MF2 area, seven stations were sampled in the MF3 area, and two additional stations were sampled between the MF1 and MF3 areas (i.e., FF1-2 and FFD-1; Figure 2-1). In addition, single stations were sampled at the outlet of Lac du Sauvage and the outlet of Lac de Gras.

A depth-integrated sampler that collects water from the surface to a depth of 10 m was used to collect phytoplankton samples from the NF, MF1, MF2, MF3 areas and the FF1-2 and FFD-1 stations. Twelve depth-integrated samples were combined from each station and the resulting composite sample was used to fill a sample bottle for phytoplankton taxonomy. Shallow water depths at LDS-4 and LDG-48 resulted in a single water sample being collected from mid-depth using a Beta-bottle.

A 75 µm mesh Wisconsin plankton net with a 30 cm mouth diameter was used to collect duplicate zooplankton samples at each station. Each sample consisted of a composite of three vertical hauls from the entire water column, beginning at a depth of 1 m from the bottom.



LEGEND

★	DIFFUSERS

STATION LOCATIONS

△	FAR-FIELD 1
▲	FAR-FIELD 2
▲	FAR-FIELD D
⬟	LAC DE GRAS OUTLET
⊕	LAC DU SAUVAGE OUTLET
●	MID-FIELD 1
●	MID-FIELD 2
●	MID-FIELD 3
●	NEAR-FIELD

→	FLOW DIRECTION
—	WATERCOURSE
▨	DIAVIK FOOTPRINT
▨	WATERBODY

0 5 10

1:175,000 KILOMETRES

REFERENCE(S)

HYDROGRAPHY DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
PROJECTION: UTM ZONE 12 DATUM: NAD 83

CLIENT

RioTinto

PROJECT

DIAVIK DIAMOND MINES (2012) INC.

CONSULTANT

GOLDER

YYYY-MM-DD	2021-03-22
DESIGNED	MC
PREPARED	LMS
REVIEWED	MC
APPROVED	RLS

TITLE

LOCATIONS OF AEMP PLANKTON SAMPLING STATIONS, 2020

PROJECT NO.	PHASE	REV.	FIGURE
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Table 2-1 Plankton Sampling Station Locations and Dates, 2020

Area	Station	Date	UTM Coordinates[a]		Distance from Diffuser[b] (m)	Water Depth (m)
			Easting (m)	Northing (m)		
NF	NF1	7-Sept-20	535740	7153854	394	22.3
	NF2	7-Sept-20	536095	7153784	501	20.6
	NF3	7-Sept-20	536369	7154092	936	18.6
	NF4	29-Aug-20	536512	7154240	1,131	21.1
	NF5	29-Aug-20	536600	7153864	968	20.6
MF1	MF1-1	31-Aug-20	535008	7154699	1,452	19.5
	MF1-3	31-Aug-20	532236	7156276	4,650	18.9
	MF1-5	31-Aug-20	528432	7157066	8,535	18.0
MF2	MF2-1	28-Aug-20	538033	7154371	2,363	18.0
	MF2-3	28-Aug-20	540365	7156045	5,386	20.3
	FF2-2	19-Aug-20	541588	7158561	8,276	19.1
	FF2-5	19-Aug-20	544724	7158879	11,444	20.0
MF3	MF3-1	27-Aug-20	537645	7152432	2,730	19.7
	MF3-2	22-Aug-20	536816	7151126	4,215	22.6
	MF3-3	22-Aug-20	536094	7148215	7,245	20.6
	MF3-4	21-Aug-20	536094	7148215	11,023	20
	MF3-5	21-Aug-20	536094	7148215	14,578	18.6
	MF3-6	21-Aug-20	536094	7148215	18,532	18.0
	MF3-7	21-Aug-20	536094	7148215	22,330	21.5
FF1	FF1-2	18-Aug-20	524932	7159476	12,915	19.0
FFD	FFD-1	18-Aug-20	522495	7155084	17,315	19.5
Outlet of Lac de Gras	LDG-48	16-Aug-20	490900	7161750	55,556	2.2
Outlet of Lac du Sauvage	LDS-4	16-Aug-20	546797	7159595	-	0.4

a) UTM coordinates are reported as Zone 12, North American Datum (NAD) 83.

b) Approximate distance from the Mine effluent diffusers along the most direct path of effluent flow.

UTM = Universal Transverse Mercator coordinate system; NF = near-field; MF = mid-field; FF = far-field.

2.2 Sample Processing and Taxonomic Identification

2.2.1 Phytoplankton Community

A total of twenty-three composite phytoplankton samples from the NF, MF, and FF areas in Lac de Gras were submitted to Biologica Environmental Services, Ltd. (Biologica), Victoria, British Columbia, for analysis of taxonomic composition, abundance, and biomass. As a result of a field crew oversight, no duplicate samples were submitted to the taxonomist in 2020. Four laboratory Quality Control (QC; split) samples were analyzed by the taxonomist, representing approximately 10% of the total samples submitted.

Following completion of the 2020 phytoplankton sample collection, DDMI was informed that the phytoplankton taxonomist selected for the AEMP (Advanced Eco-Solutions Ltd., Liberty Lake, Washington, US) would not be able to analyze the samples in 2020, or moving forward. To analyze samples in a timely manner and allow reporting of results in the 2020 AEMP Annual report, DDMI contracted a new taxonomist to complete the analysis (Biologica Environmental Services, Ltd. [Biologica]). As required by the *Quality Assurance Project Plan Version 3.1* (QAPP; Golder 2017b), a Special Study was carried out using archived AEMP samples to evaluate differences between the taxonomists (Attachment A). The 2020 phytoplankton data reported in the 2020 AEMP annual report are based on the analysis by Biologica, as summarized below.

Phytoplankton samples were homogenized by gently shaking sample containers for 60 seconds. Aliquots of 10 to 25 mL were removed and poured into settling chambers and allowed to settle for a minimum of 24 hours. Quantitative counts were done on a Carl Zeiss Axio Vert.A1 inverted phase-contrast microscope at 400× magnification. Low power scans were performed to confirm a uniform settling of the sample on the bottom of the plate and to evaluate the occurrence of rare species (Utermöhl 1958). A minimum of 250 and a maximum of 300 cells or counting units were enumerated in each sample for statistical accuracy (Lund et al. 1958). Taxonomic identifications for Biologica were based primarily on Cox (1996), Krammer and Lange-Bertalot (1986, 1988, 1991a, 1991b), Hillebrand et al. (1999), Kelly (2000), Komárek (2000), Komárek and Anagnostidis (2000a,b), John et al. (2002), Taylor et al. (2007), Wehr et al. (2015), Guiry and Guiry (2017), and Spaulding and Edlund (2020). Phytoplankton taxa were identified to the genus level, with occasional species level identifications, and abundance was reported as cells per litre (cells/L).

Fresh weight biomass was calculated from recorded abundance and biovolume estimates based on geometric solids (Rott 1981). Biovolumes were estimated from the average dimensions of 10 to 15 individuals; the biovolumes of colonial taxa were based on the number of individuals within each colony. Assuming a specific gravity of one, the biovolume of each species was converted to biomass, reported in milligrams per cubic metre (mg/m^3).

2.2.2 Zooplankton Community

A total of 42 zooplankton samples, consisting of duplicates from the NF and MF areas, and the two single stations were submitted to Salki Consultants Inc. (Salki), Winnipeg, Manitoba, Canada, for analysis of taxonomic composition. Four laboratory QC (split) samples were analyzed by the taxonomist in 2020, representing approximately 10% of the total samples submitted. Samples were analyzed for abundance and biomass of crustaceans and rotifers according to the methods provided by Salki, as summarized below. Each sample underwent three levels of analysis, as follows:

- A 1/40 or 1/80 portion of each sample was examined under a compound microscope at 63× to 160× magnification. All specimens of crustaceans and rotifers were identified to the lowest taxonomic level (typically species) and assigned to size categories as indicated in the species list.
- A second sub-sample, representing 11% of the sample volume, was examined under a stereoscope at 12× magnification for large species (e.g., *Heterocope septentrionales*, *Holopedium gibberum*, *Daphnia middendorffiana*, and *Daphnia longiremis*) and rare species (e.g., *Eubosmina longispina*, *Diaptomus ashlandi*, *Epischura nevadensis, Chydorus sphaericus*, and *Cyclops capillatus*). These were enumerated and assigned to size classes.
- The entire sample was examined under the stereoscope to improve abundance estimates for the largest species (e.g., adult male and female *Heterocope septentrionales*, *Holopedium gibberum*, *Daphnia middendorffiana*, and *Daphnia longiremis*).

Cyclopoida and Calanoida specimens (mature and immature) were identified to species, with the exception of nauplii, which were classified as either Calanoida or Cyclopoida, as appropriate. Cladocera were identified to species. Rotifers were identified to genus. Zooplankton abundance was reported as individuals per litre (ind/L). Taxonomic identifications were based primarily on Brooks (1957), Wilson (1959) and Yeatman (1959).

Biomass estimates for each taxon were obtained using mean adult sizes determined during the analysis of the 2007 zooplankton samples (Golder 2008) and from length-weight regression equations developed by Malley et al. (1989). Additional measurements were made on all newly encountered species. Zooplankton biomass was reported in units of mg/m^3.

2.3 Quality Assurance/Quality Control

The *Quality Assurance Project Plan Version 3.1* (Golder 2017b) outlines the quality assurance/quality control (QA/QC) procedures employed to support the collection of scientifically defensible and relevant data to meet the objectives of the AEMP. The QAPP is designed so that field sampling, laboratory analysis, data entry, data analysis, and report preparation activities produce technically-sound and scientifically defensible results. A description of the QA/QC program is provided in Attachment B.

Data screening of 2020 phytoplankton and zooplankton community datasets did not identify anomalous values. The duplicate zooplankton samples were within the expected range of natural variability and the split phytoplankton and zooplankton samples did not exceed the acceptance criteria. Therefore, the phytoplankton and zooplankton community datasets were deemed acceptable and used to complete the plankton community analysis in 2020.

2.4 Data Analysis

2.4.1 Data Screening

Initial screening of the 2020 plankton data was completed prior to data analyses to identify anomalous values and decide whether to retain or exclude anomalous data from further analysis. The anomalous data screening approach for AEMP component datasets was approved as part of the *2011 to 2013 Aquatic Effects Re-evaluation Report Version 3.2* (Golder 2016). The 2020 plankton community dataset did not contain any anomalous data (Attachment B); therefore, the plankton data were deemed acceptable to complete the plankton community analyses.

2.4.2 Plankton Community Analysis

The following methods were used to summarize the 2020 phytoplankton and zooplankton data:

- Abundance and biomass data were divided into the major ecological groups present in the 2016 samples. For phytoplankton these groups were diatoms, microflagellates, cyanobacteria, dinoflagellates, and chlorophytes, and for zooplankton, they were cladocerans, calanoids, cyclopoids, and rotifers.
- For zooplankton, mean abundance and biomass were calculated for each set of duplicate pairs.

- For phytoplankton, richness was calculated at the genus level for all ecological groups, while for zooplankton, richness was calculated at the lowest taxonomic level: species for cladocerans, cyclopoids, and calanoids; and genus for rotifers.
- The relative abundance and biomass (expressed as a percentage) of each major group was calculated for each sampling area and summary plots were created using the statistical environment R.
- Descriptive statistics (i.e., sample size, minimum, maximum, median, mean, and standard deviation) were calculated for total biomass, the biomass of each major ecological group, and taxonomic richness.
- Box-plots showing the mean, median, and range in the 2020 data from the NF, MF, and FF areas of Lac de Gras for total biomass and the biomasses of the major ecological groups were prepared using the statistical environment R.
- A summary of the dominant taxa found in the NF area compared to the FF areas was prepared. Dominant taxa in each area in Lac de Gras and Lac du Sauvage were identified as those with proportions greater than 10% of the total biomass in their respective sampling area.

Since toxicological impairment is expected to result in declines in most plankton variables relative to the reference condition, one-tailed tests are usually performed to assess if the NF area mean biomass and richness are significantly lower than the reference condition mean. However, this test was not performed in 2020, because both total biomass and taxonomic richness were above the reference condition mean, for both phytoplankton and zooplankton.

2.4.3 Normal Ranges

The magnitudes of effect on plankton communities were evaluated by comparing plankton variables (i.e., total biomass, richness, and the total biomass of each major ecological group) in the NF area to background values. Background values for Lac de Gras are those that fall within the range of natural variability, referred to as the normal range. Normal ranges were obtained from the *AEMP Reference Conditions Report Version 1.4* (Golder 2019a) and are summarized in Table 2-2.

Table 2-2 Normal Ranges for Plankton

Variable	Unit	Normal Range	
		Lower Limit	Upper Limit
Phytoplankton			
Total phytoplankton taxonomic richness	No. of taxa	19	36
Total phytoplankton biomass	mg/m^3	19	385
Total microflagellate biomass	mg/m^3	13	72
Total diatom biomass	mg/m^3	0	13
Total chlorophyte biomass	mg/m^3	0	309
Total cyanobacteria biomass	mg/m^3	0	48
Total dinoflagellate biomass	mg/m^3	0	40
Zooplankton			

Table 2-2 Normal Ranges for Plankton (continued)

Variable	Unit	Normal Range	
		Lower Limit	Upper Limit
Total zooplankton taxonomic richness	No. of taxa	11	17
Total zooplankton biomass	mg/m^3	132	540
Total cladoceran biomass	mg/m^3	8	127
Total calanoid biomass	mg/m^3	61	359
Total cyclopoid biomass	mg/m^3	13	105
Total rotifer biomass	mg/m^3	2	7

Source: *AEMP Reference Conditions Report Version 1.4* (Golder 2019a).

2.4.4 Statistical Analysis

2.4.4.1 Gradient Analysis

To visually evaluate spatial trends relative to the Mine discharge, total phytoplankton and zooplankton biomass and taxonomic richness at individual stations were plotted against distance from the effluent exposure. The plots also included the normal ranges for each variable for transparency. Values from Lac du Sauvage were included on the plots for comparison purposes only; the normal range does not apply to the Lac du Sauvage stations.

Spatial gradients in phytoplankton and zooplankton community variables were also evaluated along each of the transects using linear regressions, per the *AEMP Design Plan Version 4.1* (Golder 2017a). The NF area data were included in the linear regression for each of the three transects (i.e., MF1, MF2, MF3). Linear regressions were completed, regardless of statistical significances detected among sampling areas using ANOVA. All stations were included in the analysis, except LDG-48 and LDS-4. Regression analyses were considered significant at $\alpha = 0.05$.

Due to the inherent variability in the phytoplankton and zooplankton community datasets, variables often had non-linear patterns with distance from the effluent exposure. Therefore, the analysis method allowed for piecewise regression (also referred to as segmented or broken stick regression). The following approaches were used:

- Model 1: a linear multiplicative model, with main effects of distance from the effluent exposure, gradient (MF1, MF2, MF3 transects), and their interactions
- Piecewise modelling to account for changes in spatial gradients, where individual transects were analyzed separately from one another:
  - Model 2: a linear multiplicative model with main effects of distance from the effluent exposure, gradient (MF1 and MF2 transect) and their interaction
  - Model 3: a linear piecewise (broken stick) model with distance (MF3 only)

For each variable, Model 1 was used to test for the presence of a significant (*P*<0.05) breakpoint using the Davies test (Davies 1987, 2002). If a significant breakpoint was identified, Models 2 and 3 were used. If no significant breakpoint was identified, Model 1 was used.

Following the initial fit of the model, the residuals (of either Model 1 or Model 2, as applicable) were used to examine whether data needed to be transformed to meet regression assumptions. Model 3 was not considered for transformations, because the addition of breakpoint was expected to resolve non-linear patterns. For each response variable, the data underwent Box-Cox transformations (Box and Cox 1964). The Box-Cox transformations are a family of transformations that include the commonly used log and square root transformations. The Box-Cox transformation process tests a series of power values, usually between -2 and +2, and records the log-likelihood of the relationship between the response and the predictor variables under each transformation. The transformation that maximizes the log-likelihood is the one that will best normalize the data. Therefore, the data are transformed using a power value (λ) identified by the transformation process. For a λ of zero, the data are natural log transformed. The transformation rules can be described using the following definitions:

$$\text{Transformed value} = \frac{\text{value}^{\lambda} - 1}{\lambda}\ ,\ \text{if}\ \lambda \neq 0$$

$$\text{Transformed value} = \ln(\text{value})\ ,\ \text{if}\ \lambda = 0$$

The selected transformation was applied to all data (i.e., if piecewise modelling was used, a transformation selected based on Model 2 was also applied to MF3 data used in Model 3).

Following data transformation (if required), the selected models were fitted to the data. Statistical outliers were identified using studentized residuals with absolute values of 3.5 or greater, or due to consideration of leverage (where a single point could strongly influence the overall fit of the model). All values removed from the analysis were retained for plots of model predictions, where they were presented using a different symbol from the rest of the data.

Following removal of outliers, breakpoint significance and data transformation were re-examined. Residuals from the refitted models were examined for normality and heteroscedasticity, and evidence of nonlinear patterns. If non-linearity was evident from residual examination, the analysis was terminated and data were presented qualitatively. If residual assessments did not suggest that assumption of linearity or residual normality were violated, then three models were constructed to assess the effect of heteroscedasticity for each response variable in each season:

- heteroscedasticity by gradient (applied only to Models 1 and 2)
- heteroscedasticity by predicted value (accounting for the classic trumpet shape of heteroscedastic data)
- heteroscedasticity by distance from the effluent exposure

These three models were compared to the original model that did not account for heteroscedasticity, using Akaike's information criterion (AIC), corrected for small sample size (AICc). The model with the lowest AICc score among a set of candidate models was interpreted to have the strongest support, given the set of examined models and the collected data (Burnham and Anderson 2002), and thus was selected for interpretation. When using AIC not corrected for small sample size, models with AIC scores within two units of each other are considered to have similar levels of support (Arnold 2010). Since the small sample size correction was used in the analysis, the cut-off value was adjusted to reflect the higher penalization of model parameters (i.e., the adjustment depended on the number of data points and model parameters).

The constructed models were used to produce the following outputs:

- Estimates and significance of slopes (i.e., distance effects) for each gradient; in the case of MF3 data analyzed using piecewise regression, the significance of the first slope, extending from the NF to the breakpoint, was estimated.
- The r^2 value of each model, to examine explained variability.
- Fitted prediction lines and 95% confidence intervals (back-transformed to original scale of the variable).

Analyses were performed using the statistical environment R and package “segmented” (Muggeo 2008).

2.5 Action Level Evaluation

The importance of effects on phytoplankton and zooplankton was categorized according to the Action Levels in the Response Framework presented in the *AEMP Design Plan Version 4.1* (Golder 2017a). The main goal of the Response Framework is to ensure that significant adverse effects never occur. This is accomplished by requiring proponents to take actions at predefined Action Levels, which are triggered well before significant adverse effects could occur. A significant adverse effect, as it pertains to aquatic biota, was defined in the Environmental Assessment for the Mine as a change in fish population(s) that is greater than 20% (Government of Canada 1999). The effect must have a high probability of being permanent or long-term in nature and must occur throughout Lac de Gras. The Significance Thresholds for all aquatic biota, including plankton are, therefore, related to effects that could result in a change in fish population(s) that is greater than 20%.

The AEMP addresses two broad impact hypotheses for Lac de Gras: the toxicological impairment hypothesis and the nutrient enrichment hypothesis (Golder 2017a). Action Levels for the plankton component address the toxicological impairment hypothesis, while the nutrient enrichment hypothesis is addressed in the *Eutrophication Indicators Report* (Appendix XIII). Conditions required to trigger Action Levels 1 to 3 for plankton are defined in Table 2-3. Conditions for Action Level 4 would be defined if Action Level 3 was triggered. Defining further Action Levels after initial effects are encountered is consistent with the draft guidelines for preparing a Response Framework in AEMPs (WLWB 2010; Racher et al. 2011).

Phytoplankton and zooplankton biomass and taxonomic richness are assessed annually, during both interim and comprehensive sampling years. This involves statistically comparing plankton biomass and richness in the NF area (and potentially MF areas) to the reference condition (Table 2-3). Since toxicological impairment is expected to result in declines in most plankton variables relative to the reference condition, Action Level 1 is triggered if the mean value in the NF area is significantly lower than the mean of the reference condition dataset. Action Level 2 is triggered when the effect observed in the NF area expands to the nearest MF stations (i.e., MF1-1, MF2-1, MF3-1), and Action Level 3 is triggered when NF area results are less than the normal range.

Table 2-3 Action Levels for Plankton Effects

Action Level	Plankton	Extent	Action
1	Mean biomass or richness significantly less than *reference condition mean*[(a)]	NF	Confirm effect
2	Mean biomass or richness significantly less than *reference condition mean*[(a)]	Nearest MF station	Investigate cause
3	Mean biomass or richness less than normal range[(b)]	NF	Examine ecological significance Set Action Level 4 Identify mitigation options
4	TBD[(c)]	TBD[(b)]	Define conditions required for the Significance Threshold
5[(d)]	Decline in biomass or richness likely to cause a >20% change in fish population(s)	FFA	Significance Threshold

a) The reference condition dataset was obtained from the *AEMP Reference Conditions Report Version 1.4* (Golder 2019a).

b) Normal ranges were obtained from the *AEMP Reference Conditions Report Version 1.4* (Golder 2019a).

c) To be determined if Action Level 3 is triggered.

d) Although the Significance Threshold is not an Action Level, it is shown as the highest Action Level to demonstrate escalation of effects towards the Significance Threshold.

Note: Text in *italics* has been changed relative to wording in the *AEMP Design Plan Version 4.1* (Golder 2017a), to reflect the approved change in the biological Action Level assessment method by WLWB (2019) in Directive 3Q.

> = greater than; NF = near-field; MF = mid-field; FF = far-field.

3 RESULTS

The 2020 raw phytoplankton abundance and biomass data, as well as a list of phytoplankton taxa collected in Lac de Gras in 2020, and summary statistics for total phytoplankton biomass and the biomass of the major ecological groups are provided in Attachment C.

The 2020 raw zooplankton abundance and biomass data, as well as a list of zooplankton taxa collected in Lac de Gras in 2020, and summary statistics for total zooplankton biomass and the biomass of the major ecological groups are provided in Attachment D.

3.1 Phytoplankton Community

3.1.1 Phytoplankton Taxonomic Richness and Biomass

In total, 64 taxa were identified in the phytoplankton samples collected from Lac de Gras in 2020; 37 taxa were identified at LDS-4 and 31 taxa were identified at LDG-48 (Attachment C, Table C-4). Phytoplankton taxonomic richness was within or above the normal range in all areas of Lac de Gras in 2020 (Figure 3-1, Table 3-1). Mean taxonomic richness in the NF area was above the reference condition mean in 2020 (Table 3-1).

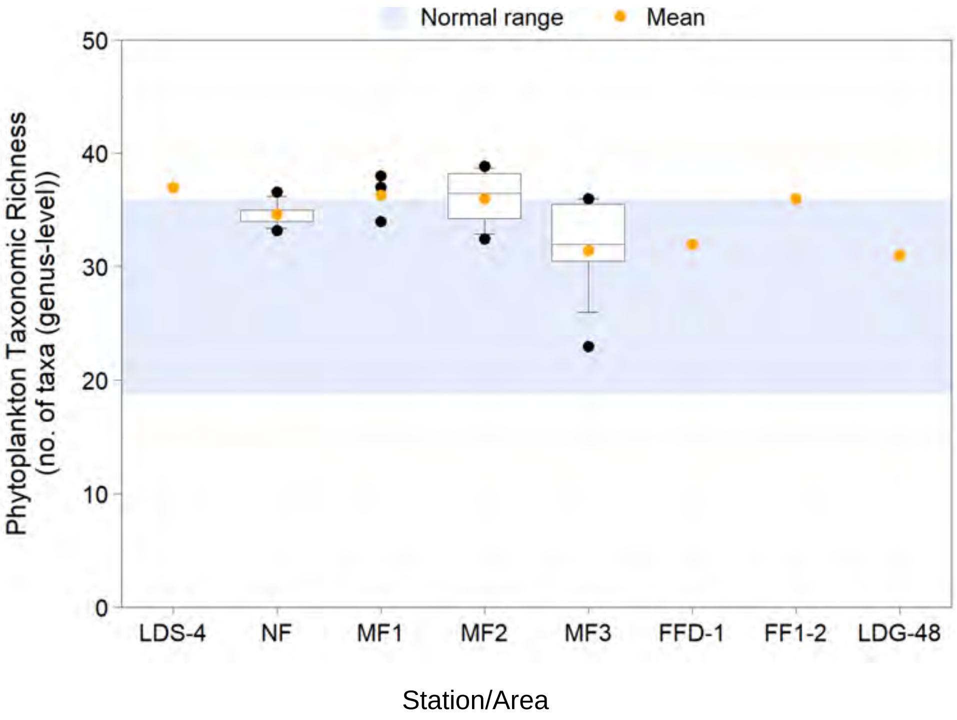
In 2020, mean phytoplankton biomass in all sampling areas was within or above the normal range (Table 3-1; Figure 3-2). Phytoplankton biomass at stations in NF area was above the normal range (Figure 3-2). Mean phytoplankton biomass was highest in the NF area, followed by the MF1 area, MF2 and MF3 areas. Phytoplankton biomass at LDS-4 was similar to that observed at MF1 and biomass values observed at FFD-1, FF1-2 and LDG-48 were similar or below the means observed in the MF2 and MF3 areas.

As noted above, the 2020 results are based on taxonomy performed by a different taxonomist (Biologica) than those used to generate the data for estimating normal ranges for phytoplankton (Eco-Logic Ltd. [Eco-logic], Vancouver, British Columbia [BC]; Section 2.2.1). The results of the taxonomist comparison, provided in Attachment A, describe some differences between taxonomists based on a subset of AEMP samples. Because of internal consistency within a dataset provided by one taxonomist, these differences are of minimal concern regarding the evaluation of effects during the 2020 AEMP (e.g., using gradient analysis and visual comparisons of community composition along the effluent exposure gradient). However, comparisons to normal ranges and reference conditions can present issues. The results of comparisons show that total phytoplankton biomass, and biomass of the dominant phytoplankton group (microflagellates), are similar between datasets produced by the two taxonomists; therefore, these variables can be compared to normal ranges that were adjusted during previous data analyses to match the data produced by Eco-Logic. However, comparing richness, and biomass of other groups to normal ranges is less likely to produce reliable results, given the greater observed differences between taxonomists for those variables. Although comparison to normal ranges for most major groups may no longer be accurate, the ability to detect Mine-related effects is not compromised, because those effects are best detected using gradient analysis, and overall level of productivity can still be evaluated based on comparison of total phytoplankton biomass to the normal range.

During annual AEMP data analysis, Action Level exceedances are evaluated by comparisons of total biomass and richness to the reference condition dataset. As described above, the switch in taxonomist does not negatively influence the Action Level evaluation for total phytoplankton. However, given that Biologica identified a greater number of genera than Eco-logic, comparison of the 2020 richness data to the normal range reflecting taxonomy by Eco-Logic does not yield realistic results, and is less likely to result in an Action Level trigger compared to previous years. To remedy this situation, it is recommended that either richness be dropped from the Action Level evaluation for phytoplankton, or the normal range for phytoplankton richness be adjusted to reflect the difference between taxonomists, by shifting it upwards by an appropriate number based on the difference between taxonomists (Attachment A).

Different responses were observed in the major ecological groups between the NF area and MF areas in 2020, and between the NF area and reference conditions (Table 3-2; Figure 3-2). Mean microflagellate and diatom biomass in all areas of Lac de Gras and LDS-4 was above the normal range in 2020. Mean microflagellate biomass followed a similar pattern to that observed in total phytoplankton biomass. Mean diatom biomass was higher in the NF area compared to other areas, but biomass at FFD-1 was similar to the NF area mean. Mean chlorophyte and dinoflagellate biomass in all areas of Lac Gras and LDS-4 was within the normal range, and mean dinoflagellate biomass in the NF area was higher than in other areas. Mean chlorophyte biomass at MF1 was greater than that observed in the NF area, but at LDS-4 it was similar to that observed in the NF area. Cyanobacteria biomass was notably higher at LDS-4 compared to Lac de Gras. In Lac de Gras, mean cyanobacteria biomass was above the normal range and was similar among the NF, MF1, and MF2 areas in 2020.

Figure 3-1 Phytoplankton Taxonomic Richness by Sampling Area in Lac de Gras and Lac du Sauvage, 2020



Note: boxplots represent the 10th, 25th, 50th (i.e., median), 75th, and 90th percentile concentrations in each sampling area. The black dots in the boxplots represent the 5th (on the bottom) and 95th (on the top) percentiles.

NF = near-field; MF = mid-field; FF = far-field; LDS = Lac du Sauvage; LDG = Lac de Gras.

Table 3-1 Phytoplankton Biomass and Taxonomic Richness in the NF Area of Lac de Gras in 2020 Compared to the Normal Range

Variable	Unit	2020 NF		Normal Range(a)			
		n	Mean ± SD	n	Lower Limit	2013 Mean	Upper Limit
Total phytoplankton taxonomic richness(b)	no. of taxa	5	35 ± 2	15	19	27	36
Total phytoplankton biomass	mg/m^3	5	**526** ± 163	15	19	200	385
Microflagellate biomass	mg/m^3	5	**337** ± 73	15	13	56	72
Diatom biomass	mg/m^3	5	**116** ± 95	15	0	5	13
Chlorophyte biomass	mg/m^3	5	28 ± 32	15	0	104	309
Cyanobacteria biomass	mg/m^3	5	7 ± 4	15	0	28	48
Dinoflagellate biomass	mg/m^3	5	38 ± 16	15	0	11	40

a) Normal ranges were obtained from the *AEMP Reference Conditions Report Version 1.4* (Golder 2019a); however, the mean is based on the 2013 data.

b) Taxonomic richness is the number of taxa at the genus level.

Note: **Bolded** NF area means are outside the normal range.

n = number of samples; ± = plus or minus; SD = standard deviation; NF = near-field.

Table 3-2 Summary Statistics for Phytoplankton Biomass and Taxonomic Richness in the NF and MF Areas of Lac de Gras, 2020

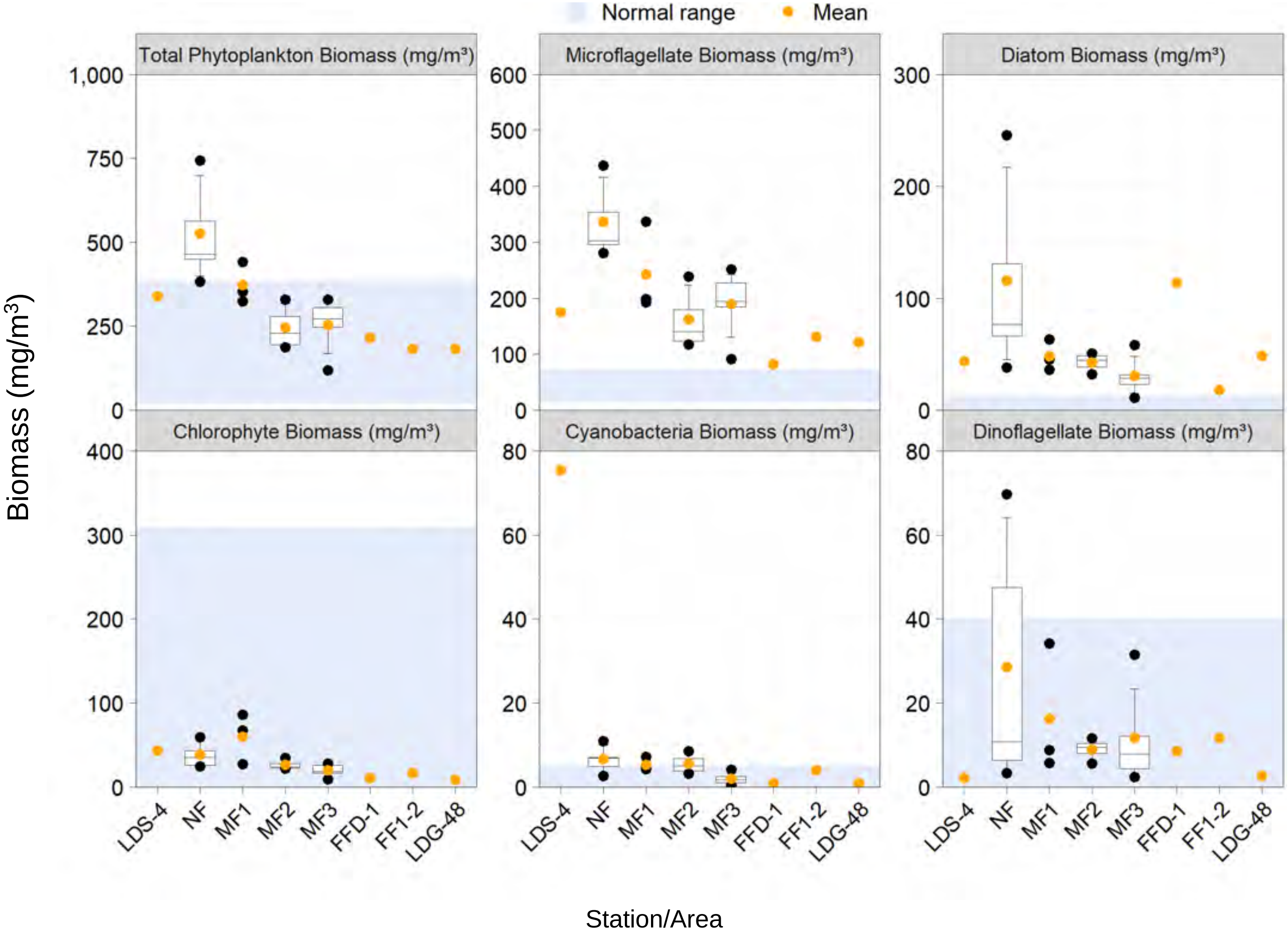
Area		Total phytoplankton biomass	Total phytoplankton taxonomic richness[a]	Microflagellate biomass	Diatom biomass	Cyanobacteria biomass	Dinoflagellate biomass	Chlorophyte biomass
		mg/m^3	No. of taxa	mg/m^3	mg/m^3	mg/m^3	mg/m^3	mg/m^3
NF	Count	5	5	5	5	5	5	5
	Minimum	366	33	277	31	2	24	3
	Maximum	789	37	457	274	12	63	75
	Median	464	34	303	77	7	35	11
	Mean	526	35	337	116	7	38	28
	Standard Deviation	163	2	73	95	4	16	32
MF1	Count	3	3	3	3	3	3	3
	Minimum	323	34	193	36	4	27	6
	Maximum	440	38	337	63	7	86	34
	Median	353	37	199	45	5	67	9
	Mean	372	36	243	48	5	60	16
	Standard Deviation	61	2	82	14	2	30	16
MF2	Count	4	4	4	4	4	4	4
	Minimum	185	32	116	30	3	21	5
	Maximum	342	39	253	51	9	36	12
	Median	229	37	140	45	5	24	9
	Mean	246	36	163	43	5	26	9
	Standard Deviation	71	3	63	9	3	7	3
MF3	Count	7	7	7	7	7	7	7
	Minimum	67	20	51	8	0	7	2
	Maximum	330	36	260	69	5	29	40
	Median	273	32	195	28	2	18	8
	Mean	254	31	190	31	2	20	12
	Standard Deviation	89	6	67	19	1	8	13

Note: Summary statistics were not calculated for FF1-2, FFD-1, LDG-48 and LDS-4 because only a single station/sample was collected in each area.

a) Taxonomic richness is the number of taxa at the genus level.

mg/m^3 = milligrams per cubic metre; NF = near-field; MF = mid-field; LDG = Lac de Gras; LDS = Lac du Sauvage.

Figure 3-2 Phytoplankton Biomass of Major Ecological Groups by Sampling Area in Lac de Gras and Lac du Sauvage, 2020



Note: boxplots represent the 10th, 25th, 50th (i.e., median), 75th, and 90th percentile concentrations in each sampling area. The black dots in the boxplots represent the 5th (on the bottom) and 95th (on the top) percentiles.

NF = near-field; MF = mid-field; FF = far-field; LDS = Lac du Sauvage; LDG = Lac de Gras.

3.1.2 Gradient Analysis

Gradient analysis of phytoplankton richness, biomass, and the biomass of the major ecological groups indicate that richness remained similar along each transect, while total biomass decreased significantly with increasing distance away from the effluent diffusers along the MF1 and MF2 transects but not the MF3 transect (Table 3-3; Figures 3-3, 3-4, and 3-5). Although total phytoplankton biomass results were not significant along the MF3 transect according to the broken-stick models applied, visual evaluation indicates that biomass declined with distance from the diffusers. Microflagellate biomass significantly decreased with increasing distance from the effluent exposure along the MF1, MF2, and MF3 transects, chlorophyte biomass significantly decreased along the MF1 transect, and cyanobacteria and dinoflagellate biomass significantly decreased along the MF3 transect.

Table 3-3 Gradient Analysis for Phytoplankton Community Variables in Lac de Gras, 2020

Variable	Model	Transformation[a]	Gradient	Slope Direction[b]	Breakpoint (km)[c]	*P*-value	r^2 or R^2[d]
Total phytoplankton taxonomic richness[e]	Model 1	-	MF1	↓	-	0.396	-0.03
			MF2	↑	-	0.354	-0.03
			MF3	↓	-	0.495	-0.03
Total phytoplankton biomass[f]	Model 2	Log	MF1	↓	-	**0.001**	0.61
	Model 2		MF2	↓	-	**0.005**	0.61
	Model 3		MF3 (1st slope)	↓	1.36	0.086	0.75
			MF3 (2nd slope)	↓		-	0.75
Microflagellate[g] biomass	Model 1	Log	MF1	↓	-	**<0.001**	0.89
			MF2	↓	-	**<0.001**	0.89
			MF3	↓	-	**0.005**	0.89
Diatom biomass	Model 1	Log	MF1	↓	-	0.420	0.13
			MF2	↓	-	0.169	0.13
			MF3	↓	-	**0.036**	0.13
Chlorophyte[h] biomass	Model 2	Log	MF1	↓	-	**<0.001**	0.90
	Model 2		MF2	↓	-	0.070	0.90
	Model 3		MF3 (1st slope)	↓	14.58	0.056	0.67
			MF3 (2nd slope)	↓		-	0.67
Cyanobacteria biomass	Model 1	Square root	MF1	↓	-	0.052	0.36
			MF2	↓	-	0.888	0.36
			MF3	↓	-	**0.002**	0.36
Dinoflagellate biomass	Model 1	Log	MF1	↓	-	0.867	0.47
			MF2	↓	-	0.487	0.47
			MF3	↓	-	**0.005**	0.47

Notes: **Bold** indicates *P*-value significant at <0.05

a) Models used and transformation rules are described in Section 2.4.4.

b) Slope direction was represented by an upward arrow (↑) indicating an increasing trend with distance from the effluent exposure,

c) or a downward arrow (↓) indicating a decreasing trend with distance from the effluent exposure.

d) The breakpoint is the location from the effluent exposure where the slopes of the linear regressions along the MF3

e) transect changed values.

f) For the MF3 Broken stick model, r^2 is calculated because there is only one predictor, which is distance; for the other models, R^2

g) is used because there is more than one predictor, i.e., distance and gradient.

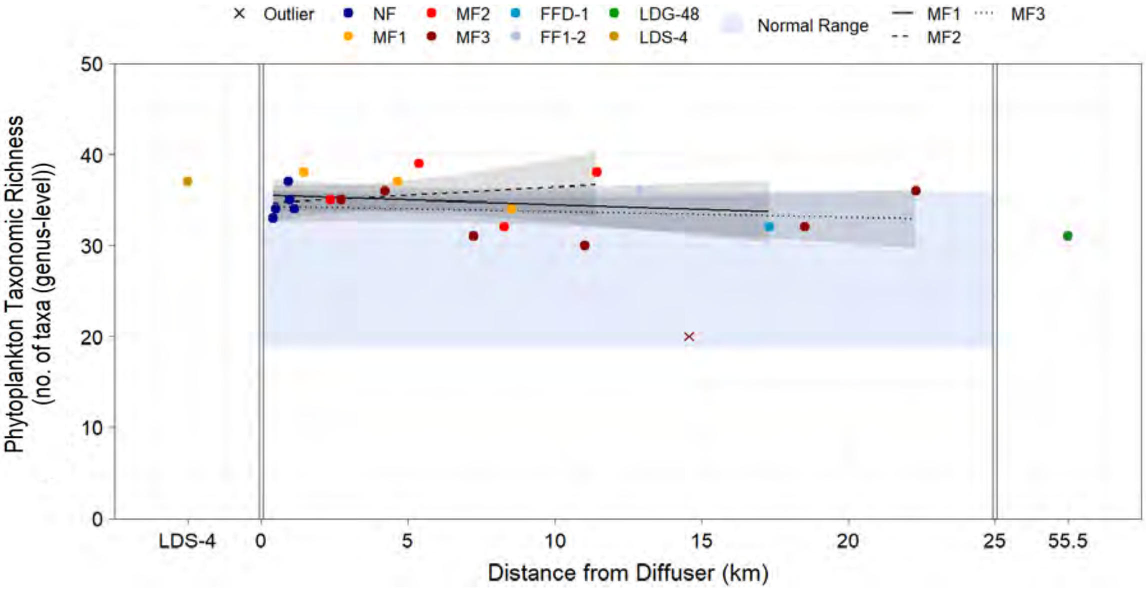
h) Outlier removed: 20 taxa/sample.

i) Outlier removed: 67 mg/m^3.

j) Outlier removed: 51 mg/m^3.

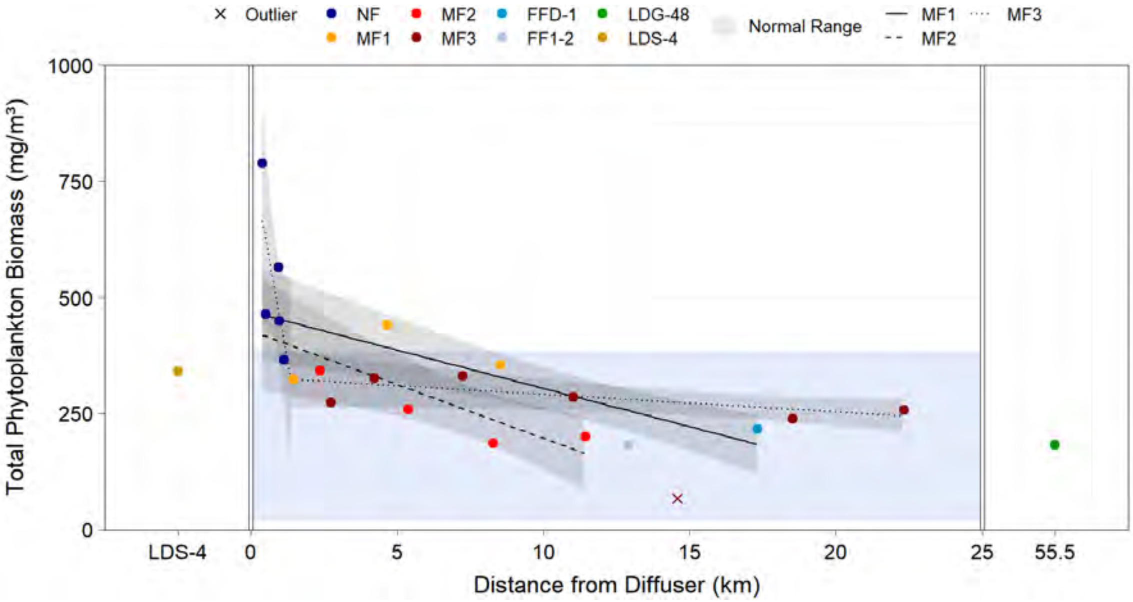
k) Outlier removed: 86 mg/m^3.

Figure 3-3 **Phytoplankton Taxonomic Richness in Lac de Gras and Lac du Sauvage Relative to Distance from the Effluent Discharge, 2020**



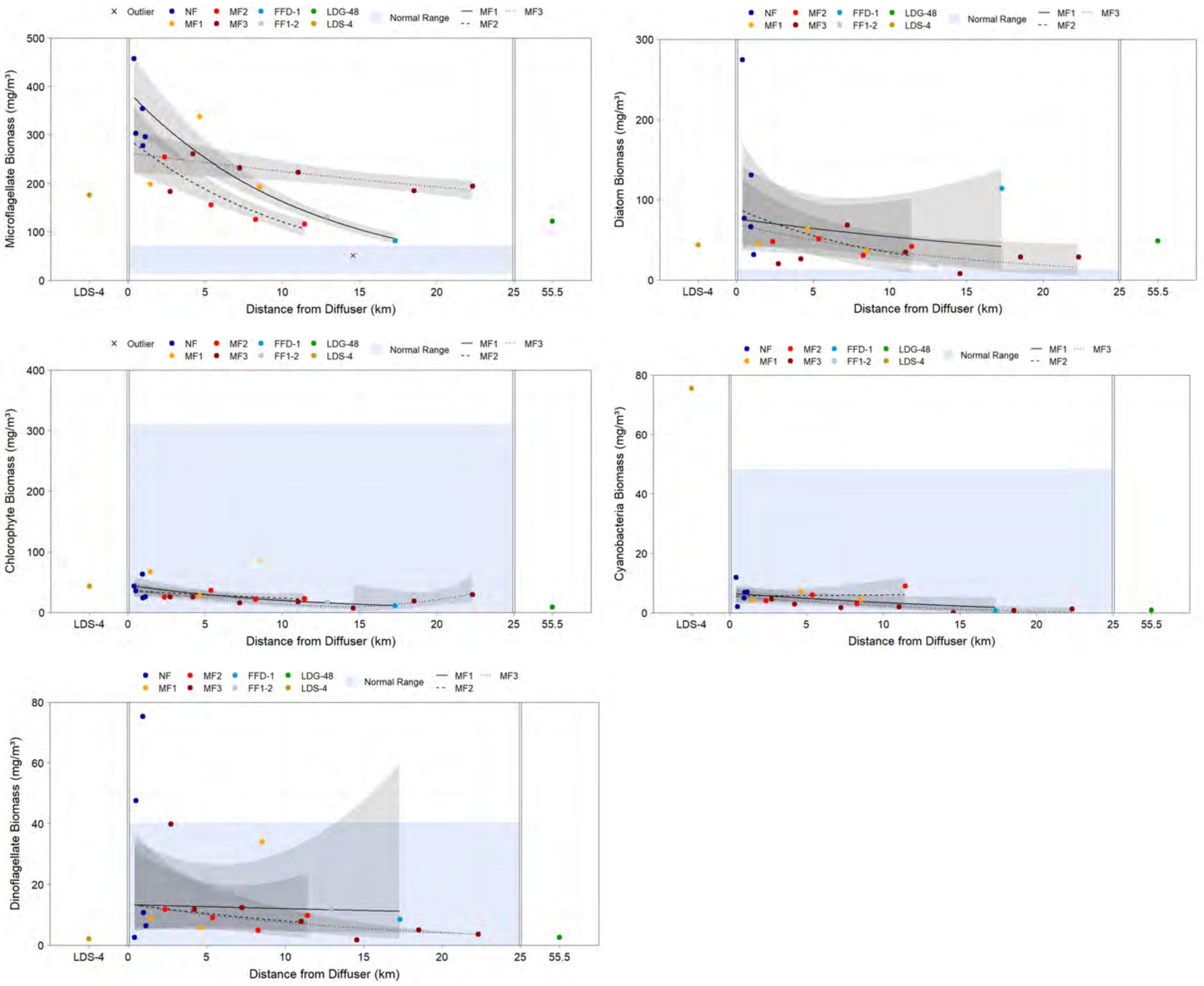
Note: Shaded bands around fitted prediction lines are 95% confidence intervals (back-transformed to original scale of the variable). NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage.

Figure 3-4 **Phytoplankton Biomass in Lac de Gras and Lac du Sauvage Relative to Distance from the Effluent Discharge, 2020**



Note: Shaded bands around fitted prediction lines are 95% confidence intervals (back-transformed to original scale of the variable). NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage.

Figure 3-5 Biomass of Major Phytoplankton Groups in Lac de Gras and Lac du Sauvage Relative to Distance from the Effluent Discharge, 2020



Note: Shaded bands around fitted prediction lines are 95% confidence intervals (back-transformed to original scale of the variable).
NF = near-field; MF = mid-field; FF = far-field; LDG = Lac de Gras; LDS = Lac du Sauvage.

3.1.3 Phytoplankton Community Structure

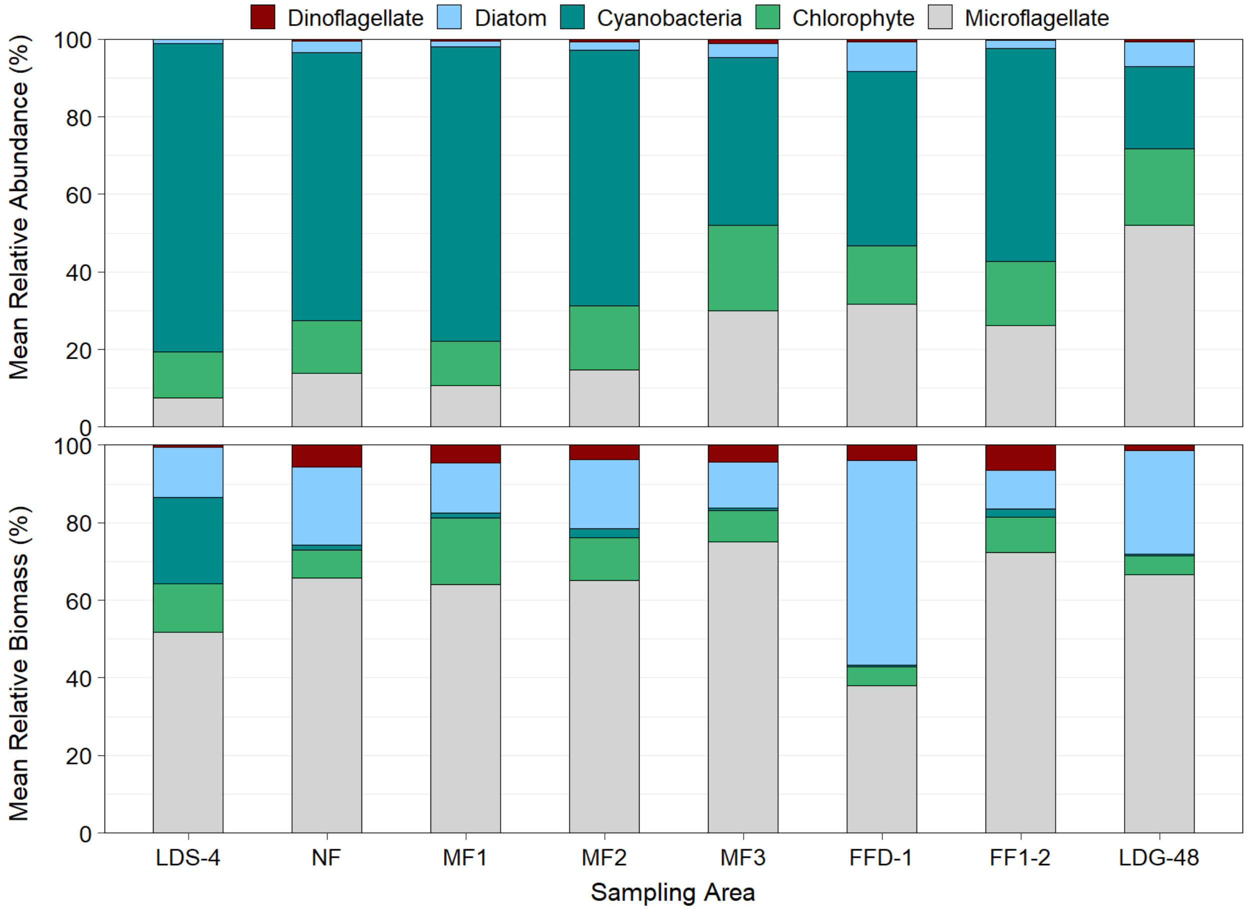
Phytoplankton community composition in the NF area of Lac de Gras did not substantially differ from the MF areas, in terms of relative abundance or biomass in 2020 (Figure 3-6). The phytoplankton communities in all areas of Lac de Gras were dominated by cyanobacteria, based on abundance, with microflagellate and chlorophyte sub-dominance, and by microflagellates and diatoms, by biomass.

The abundance results suggest a general east-west gradient in community composition (Figure 3-6). Mean relative abundance of microflagellates was greater in the MF3 area and at the FF1-2, FFD-1 and LDG-48 stations compared to the NF, MF1 and MF2 areas, and cyanobacteria abundance was greater in the NF, MF1, and MF2 areas and at LDS-4 compared to other stations located farther west. Chlorophyte, diatom, and dinoflagellate abundance was similar among areas.

Biomass results showed no consistent spatial trends in Lac de Gras (Figure 3-6). Cyanobacteria biomass was low in all areas of Lac de Gras in 2020, but was the sub-dominant group at LDS-4 (Figures 3-2 and 3-6). A higher proportion of diatoms, based on biomass, was observed at the FFD-1 station compared to other areas in Lac de Gras and dinoflagellate biomass was low at LDS-4 and LDG-48 relative other stations in Lac de Gras.

Despite accounting for a relatively large proportion of the total phytoplankton abundance, cyanobacteria accounted for a small proportion of the total biomass (i.e., approximately 1% in the NF area and approximately 2% in the MF areas), reflective of the small size of their cells. In contrast, diatoms and dinoflagellates accounted for a relatively small proportion of the phytoplankton community in terms of abundance (i.e., 4% on average in the NF area and 3% on average in the MF areas), but contributed a relatively large proportion of total phytoplankton biomass (i.e., 27% on average in the NF area and 20% on average in the MF areas) because of the comparatively large size of their cells.

Figure 3-6 **Mean Relative Phytoplankton Abundance and Biomass in Lac de Gras and Lac du Sauvage, 2020**



NF = near-field; MF = mid-field; FF = far-field; LDS = Lac du Sauvage; LDG = Lac de Gras.

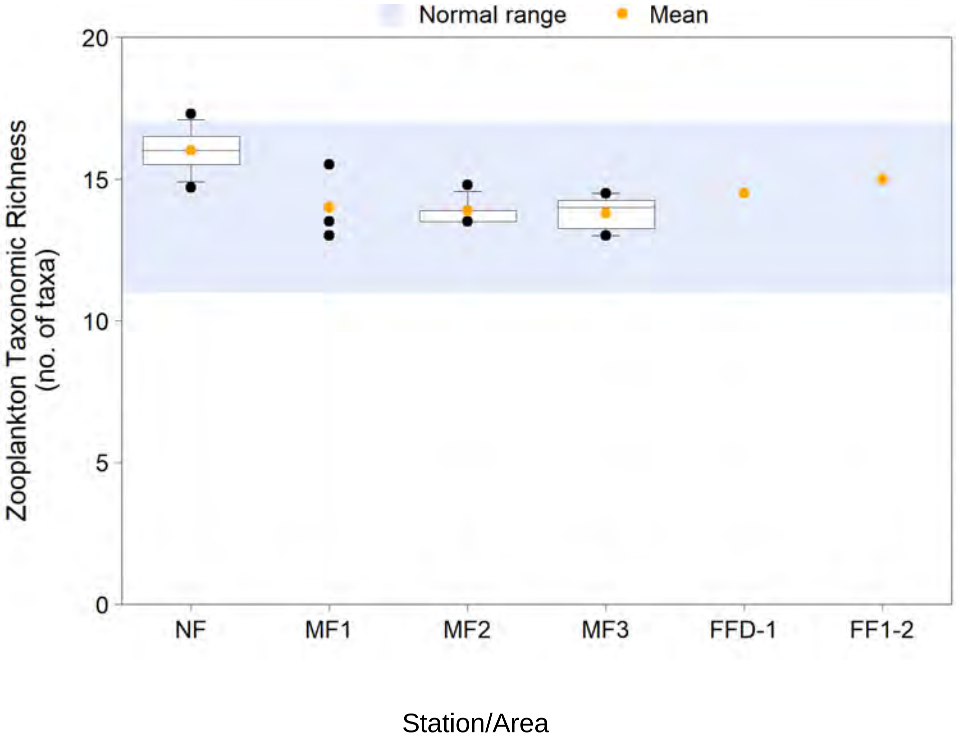
3.2 Zooplankton Community

3.2.1 Zooplankton Taxonomic Richness and Biomass

In total, 22 zooplankton taxa were identified in the zooplankton samples in 2020 (Attachment D, Table D-4). Mean zooplankton taxonomic richness in all areas of Lac de Gras was within the normal range and was greater in the NF area compared to the MF areas in 2020 (Figure 3-7; Table 3-4). Mean zooplankton taxonomic richness in the NF area was above the reference condition mean in 2020 (Table 3-4).

In 2020, mean total zooplankton biomass, and the biomass of cyclopoid and calanoid copepods, and rotifers were above the normal range in the MF1 area and greater than in other areas (Figure 3-8). Mean zooplankton biomass in the NF area was above the reference condition mean in 2020, showing no indication of toxicological impairment (Table 3-4). Mean zooplankton biomass and biomass of calanoid copepods and cladocerans were within the normal range in the NF, MF2, and MF3 areas and stations FFD-1 and FF1-2, except cladoceran biomass at FFD-1, which was above the normal range. Mean cyclopoid copepod biomass was above the normal range in all areas of Lac de Gras in 2020, and mean rotifer biomass was above the normal range in the NF, MF, and MF2 areas in 2020, but within the normal range in the MF3 area and at stations FFD-1 and FF1-2.

Figure 3-7 Zooplankton Taxonomic Richness by Sampling Area in Lac de Gras, 2020



Note: boxplots represent the 10th, 25th, 50th (i.e., median), 75th, and 90th percentile concentrations in each sampling area. The black dots in the boxplots represent the 5th (on the bottom) and 95th (on the top) percentiles.

NF = near-field; MF = mid-field; FF = far-field.

Table 3-4 Zooplankton Biomass and Taxonomic Richness in the NF Area of Lac de Gras in 2020 Compared to the Normal Range

Variable	Unit	2020 NF		Normal Range[(a)]			
		n	Mean ± SD	n	Lower Limit	2008-2010 Reference Area Mean	Upper Limit
Total zooplankton taxonomic richness	no. of taxa	5	16 ± 1	103	11	14	17
Total zooplankton biomass	mg/m^3	5	478 ± 99	103	132	288	540
Cladocera biomass	mg/m^3	5	33 ± 27	100	8	50	127
Calanoida biomass	mg/m^3	5	319 ± 72	98	61	165	359
Cyclopoida biomass	mg/m^3	5	**117** ± 29	101	13	55	105
Rotifera biomass	mg/m^3	5	**9** ± 1	96	2	4	7

a) Normal ranges were obtained from the *AEMP Reference Conditions Report Version 1.4* (Golder 2019a).

Note: **Bolded** NF area means are outside the normal range.

n = number of samples; SD = standard deviation; ± = plus or minus; NF = near-field.

Table 3-5 Summary Statistics for Zooplankton Biomass and Taxonomic Richness in the NF and MF Areas of Lac de Gras, 2020

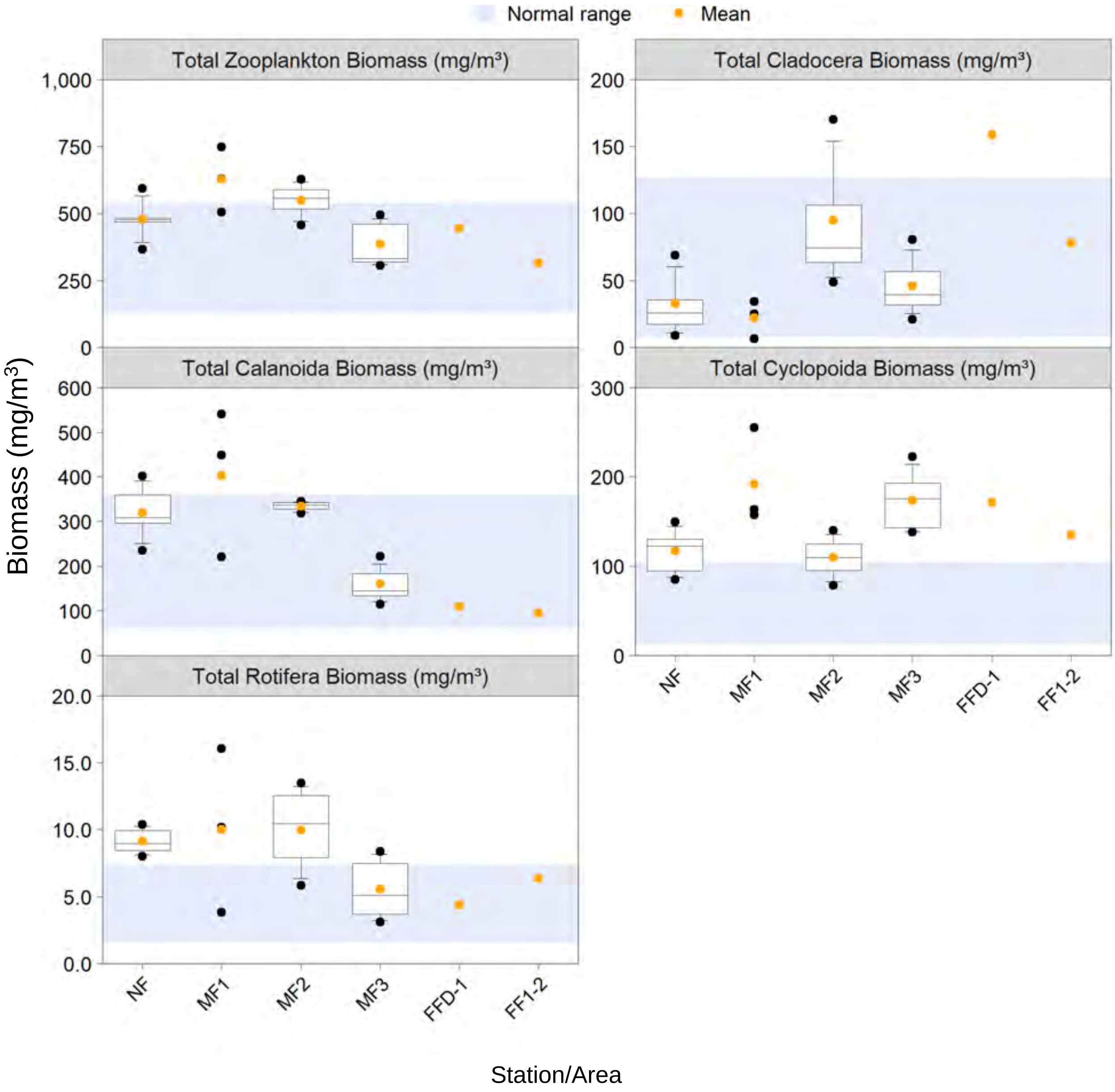
Area		Total zooplankton biomass	Total zooplankton taxonomic richness[(a)]	Cladocera biomass	Cyclopoida biomass	Calanoida biomass	Rotifera biomass
		mg/m^3	No. of taxa	mg/m^3	mg/m^3	mg/m^3	mg/m^3
NF	Count	5	5	5	5	5	5
	Minimum	341	15	7	83	221	8
	Maximum	621	18	77	154	412	10
	Median	477	16	26	122	309	9
	Mean	478	16	33	117	319	9
	Standard Deviation	99	1	27	29	72	1
MF1	Count	3	3	3	3	3	3
	Minimum	505	13	7	157	221	4
	Maximum	748	16	34	255	540	16
	Median	629	14	25	163	449	10
	Mean	627	14	22	192	403	10
	Standard Deviation	122	1	14	55	164	6
MF2	Count	4	4	4	4	4	4
	Minimum	441	13	45	75	315	5
	Maximum	638	15	186	144	345	14
	Median	558	14	74	110	337	10
	Mean	548	14	95	110	334	10
	Standard Deviation	82	1	62	29	13	4
MF3	Count	7	7	7	7	7	7
	Minimum	302	13	17	138	108	3
	Maximum	508	15	88	231	238	9
	Median	333	14	40	176	145	5
	Mean	386	14	46	174	161	6
	Standard Deviation	87	0	24	35	44	2

Note: Summary statistics were not calculated for FF1-2, FFD-1, LDG-48 and LDS-4 because only a single station/sample was collected in each area.

a) Taxonomic richness is the number of species or genera.

mg/m^3 = milligrams per cubic metre; NF = near-field; MF = mid-field; LDG = Lac de Gras; LDS = Lac du Sauvage.

Figure 3-8 Zooplankton Biomass of Major Ecological Groups by Sampling Area in Lac de Gras and Lac du Sauvage, 2020



Note: boxplots represent the 10th, 25th, 50th (i.e., median), 75th, and 90th percentile concentrations in each sampling area. The black dots in the boxplots represent the 5th (on the bottom) and 95th (on the top) percentiles.

NF = near-field; MF = mid-field; FF = far-field.; LDS = Lac du Sauvage; LDG = Lac de Gras.

3.2.2 Gradient Analysis

Gradient analysis results for zooplankton richness, total biomass and the biomass of calanoid copepods and rotifers indicated that these variables have generally decreased with increasing distance away from the effluent diffusers (Table 3-6; Figures 3-9, 3-10 and 3-11). Cyclopoid copepod and cladoceran biomass generally increased with increasing distance from the diffusers (Table 3-6; Figure 3-11). Along the MF1 transect, cladoceran biomass and cyclopoid copepod biomass significantly increased, and calanoid copepod and rotifer biomass significantly declined with increasing distance from the diffusers (Table 3-6). Along the MF2 transect, only taxonomic richness decreased significantly with increasing distance from the diffusers. Along the MF3 transect, taxonomic richness and calanoid copepod biomass declined significantly with increasing distance from the diffusers.

Table 3-6 Trend Analysis for Zooplankton Community Variables in Lac de Gras, 2020

Variable	Model	Transformation(a)	Gradient	Slope Direction (b)	*P*-value	R^{2}(c)
Total zooplankton taxonomic richness	Model 1	Log	MF1	↓	0.113	0.35
			MF2	↓	**0.008**	0.35
			MF3	↓	**0.007**	0.35
Total zooplankton biomass	Model 1	Log	MF1	↓	0.250	0.05
			MF2	↑	0.621	0.05
			MF3	↓	0.426	0.05
Cladoceran biomass	Model 1	Log	MF1	↑	**0.036**	0.18
			MF2	↑	0.098	0.18
			MF3	↑	0.107	0.18
Cyclopoid biomass	Model 1	Log	MF1	↑	**0.115**	0.19
			MF2	↓	0.267	0.19
			MF3	↑	0.126	0.19
Calanoid biomass	Model 1	Log	MF1	↓	**0.001**	0.49
			MF2	↑	0.689	0.49
			MF3	↓	**0.038**	0.49
Rotifer biomass	Model 1	Log	MF1	↓	**0.017**	0.24
			MF2	↓	0.200	0.24
			MF3	↓	0.332	0.24

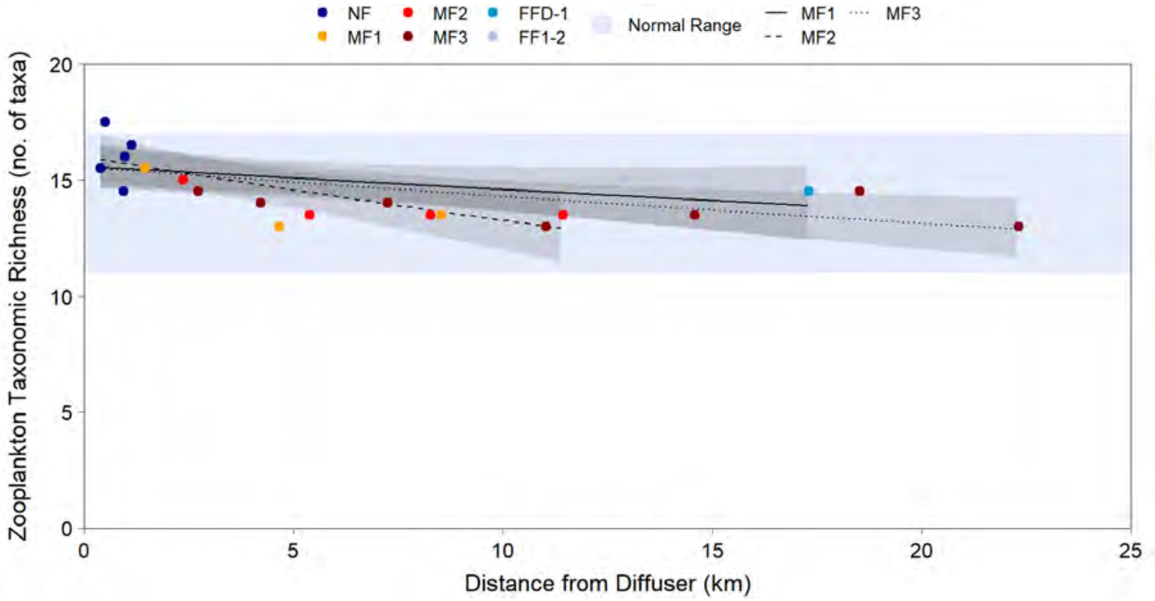
Notes: **Bold** indicates *P*-value significant at <0.05

a) Models used and transformation rules are described in Section 2.4.4.

b) Slope direction was represented by an upward arrow (↑) indicating an increasing trend with distance from the effluent exposure, or a downward arrow (↓) indicating a decreasing trend with distance from the effluent exposure.

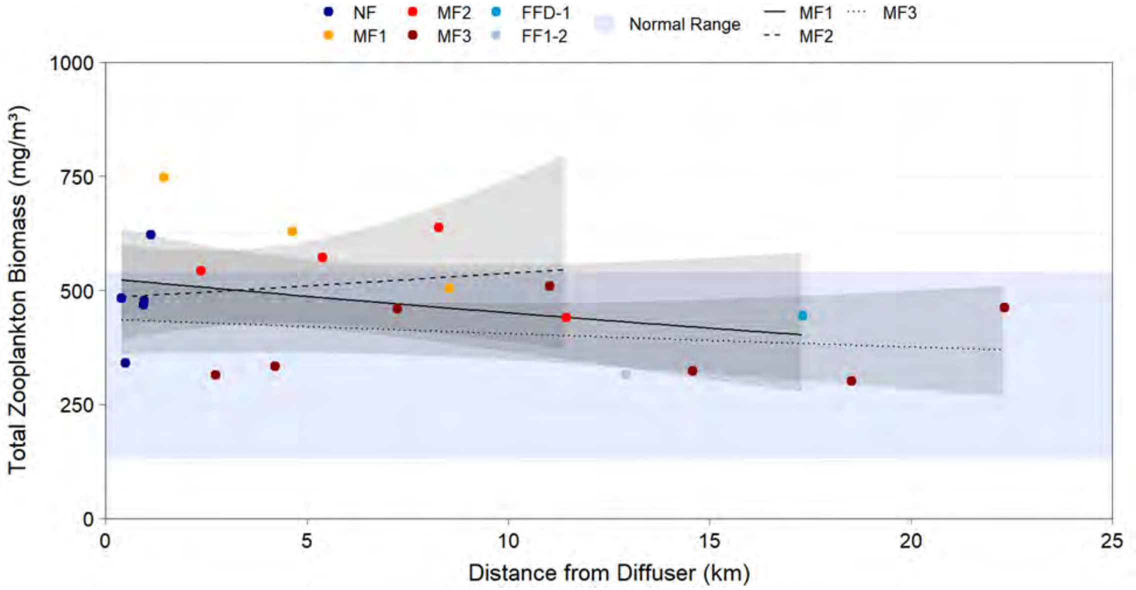
c) R^2 is shown because there is more than one predictor variable, i.e., distance and gradient

Figure 3-9 Zooplankton Taxonomic Richness in Lac de Gras and Lac du Sauvage Relative to Distance from the Effluent Discharge, 2020



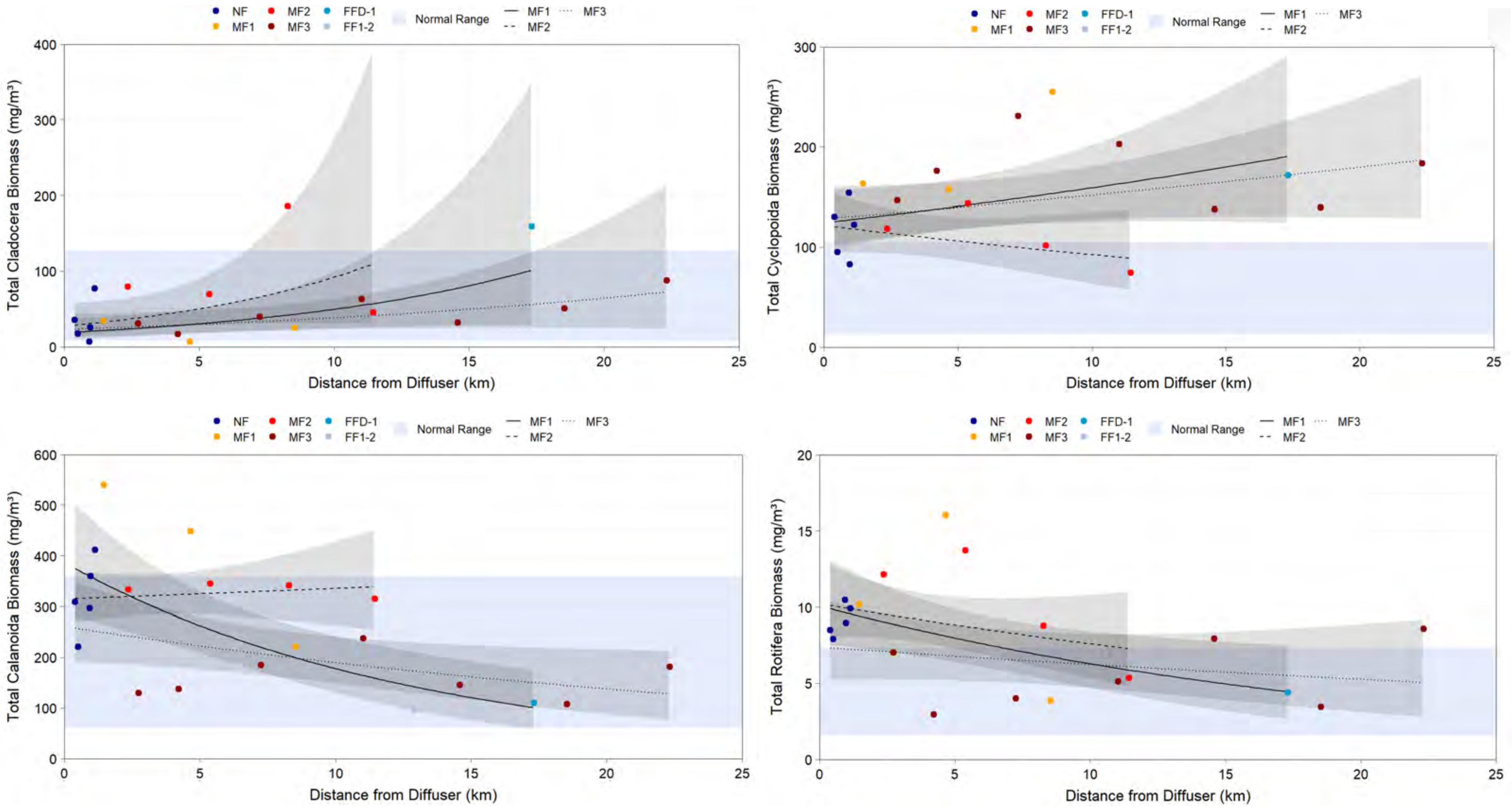
Note: Shaded bands around fitted prediction lines are 95% confidence intervals (back-transformed to original scale of the variable). NF = near-field; MF = mid-field; FF = far-field.

Figure 3-10 Zooplankton Biomass in Lac de Gras and Lac du Sauvage Relative to Distance from the Effluent Discharge, 2020



Note: Shaded bands around fitted prediction lines are 95% confidence intervals (back-transformed to original scale of the variable). NF = near-field; MF = mid-field; FF = far-field.

Figure 3-11 Biomass of Major Zooplankton Groups in Lac de Gras and Lac du Sauvage Relative to Distance from the Effluent Discharge, 2020



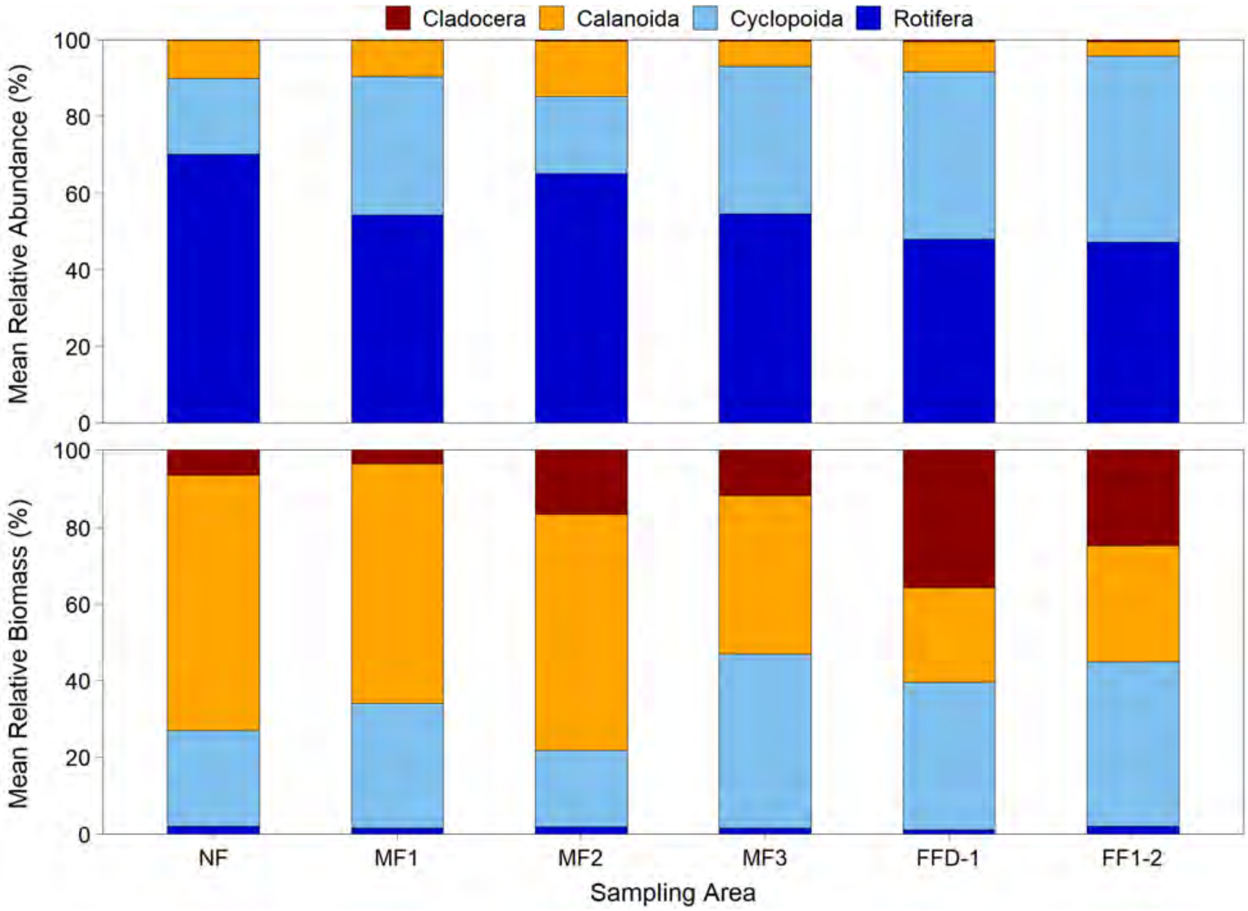
Note: Shaded bands around fitted prediction lines are 95% confidence intervals (back-transformed to original scale of the variable).
NF = near-field; MF = mid-field; FF = far-field.

3.2.3 Zooplankton Community Structure

The abundance results suggest a general east-west gradient in community composition (Figure 3-12). Zooplankton communities, based on abundance, in the NF and MF areas of Lac de Gras were co-dominated by rotifers and cyclopoid copepods in 2020 (Figure 3-12). In terms of mean relative biomass, the zooplankton community in the NF and MF areas was dominated by calanoid copepods, with cyclopoid copepod sub-dominance. There were fewer cladocerans in the NF and MF1 areas compared to the other areas, in terms of both abundance and biomass.

Despite accounting for a large proportion of total abundance, rotifers accounted for a small proportion of the total biomass (i.e., 2% in the NF area and less than 2% in the MF areas), reflective of their small body size (Figure 3-12). In contrast, calanoid copepods and cladocerans accounted for a small proportion of zooplankton community relative abundance (i.e., less than 10% in the NF area and less than 15% in the MF areas), but contributed a large proportion of total zooplankton biomass (i.e., 73% in the NF area and between 53 and 78% in the MF areas), because of their relatively large body size.

Figure 3-12 Mean Relative Zooplankton Abundance and Biomass in Lac de Gras, 2020



NF = near-field; MF = mid-field; FF = far-field.

3.3 Action Level Evaluation

The Action Levels for plankton effects address the toxicological impairment hypothesis. Action Level 1 is triggered when biomass or richness in the NF exposure area is significantly lower than the reference condition mean (Table 2-3). In 2020, the NF area mean values for total phytoplankton and zooplankton biomass and taxonomic richness were above the reference condition mean (Tables 3-1 and 3-4). Therefore, no Action Levels were triggered.

As indicated in Section 3.1.1 and Attachment A, the unanticipated switch to a different phytoplankton taxonomist in 2020 is likely to affect the comparison of phytoplankton richness to the normal range, which is an Action Level criterion. Based on results presented in Attachment A, adjusting the normal range for phytoplankton richness upwards by the currently suggested number (12) would not result in an Action Level trigger in 2020 for this variable.

4 SUMMARY AND DISCUSSION

4.1 Phytoplankton Community

Phytoplankton taxonomic richness and biomass were within or above the normal range in all areas of Lac de Gras in 2020. Mean taxonomic richness in the NF area was above the reference condition mean and mean phytoplankton biomass was above the normal range, showing no indication of toxicological impairment in 2020. Gradient analysis demonstrated that phytoplankton richness, biomass, and the biomass of the major ecological groups decreased with distance from the diffusers, and that stations close to the effluent exposure (i.e., stations in the NF area) generally have higher richness and biomass than the more distant stations in 2020. These results are consistent with a Mine-related nutrient enrichment effect.

Phytoplankton community composition in the NF area of Lac de Gras did not substantially differ from the MF areas, in terms of relative abundance or biomass in 2020. The phytoplankton communities in all areas of Lac de Gras were dominated by cyanobacteria based on abundance, with microflagellate and chlorophyte sub-dominance, and by microflagellates and diatoms by biomass.

Overall, the 2020 phytoplankton results did not provide evidence of toxicological impairment and Action Level 1 for toxicological impairment was not triggered based on phytoplankton taxonomic richness or biomass. The 2020 phytoplankton biomass results are consistent with the chlorophyll *a* results presented in the 2020 Eutrophication Indicators Report (Appendix XIII).

4.2 Zooplankton Community

Mean zooplankton taxonomic richness in all areas of Lac de Gras was within the normal range, was greater in the NF area compared to the MF areas, and was above the reference condition mean in 2020. Mean total zooplankton biomass in the NF area was within the normal range in 2020 but above the reference condition mean. In the NF area, mean biomass of calanoid copepods and cladocerans were within the normal range and cyclopoid copepod and rotifer biomass was above the normal range.

The gradient analysis of zooplankton richness, biomass and the biomass of the major ecological groups indicated that the zooplankton variables have generally not shown a decrease close to the effluent diffusers; rather, richness, total biomass, and biomass of calanoid copepods and rotifers have generally declined with distance away from the effluent diffusers, consistent with nutrient enrichment.

Zooplankton communities, based on abundance, in the NF and MF areas of Lac de Gras were co-dominated by rotifers and cyclopoid copepods in 2020. In terms of mean relative biomass, the zooplankton community in the NF and MF areas was dominated by calanoid copepods, with cyclopoid copepod sub-dominance. There were fewer cladocerans in the NF and MF1 areas compared to the other areas, in terms of both abundance and biomass.

The 2020 zooplankton community did not show a response consistent with toxicological impairment and Action Level 1 for toxicological impairment was not triggered. Rather, results were consistent with Mine-related nutrient enrichment, as demonstrated by greater zooplankton biomass in the NF area compared to the MF2 and MF3 areas, and the reference condition mean. Results reported in the *Eutrophication Indicators Report* (Appendix XIII) also indicate that nutrient enrichment is occurring in Lac de Gras.

5 RESPONSE FRAMEWORK

In 2020, the NF area mean values for total phytoplankton and zooplankton taxonomic richness and biomass were above the reference condition mean, indicating that Action Level 1 was not triggered.

6 CONCLUSIONS

This report presents the analysis of the phytoplankton and zooplankton data collected during the 2020 AEMP field program. It addresses the objectives of the interim plankton program, which are to evaluate the current year's plankton community data according to the AEMP Response Framework, to evaluate whether Mine-related toxicological changes are occurring in the plankton community in the NF area of Lac de Gras, and to assess the spatial extent of Mine-related effects within the NF and MF areas.

Overall, the 2020 plankton data indicate that a toxicological effect is not occurring in Lac de Gras. Rather, results continue to be consistent with nutrient enrichment[1] originating from nutrients discharged by Mine effluent, as demonstrated by greater plankton biomass in the NF area compared to the MF areas and the reference condition mean. The NF area mean values for total phytoplankton and zooplankton taxonomic richness and biomass were greater than the reference condition mean[2], indicating that Action Level 1 was not triggered.

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[1] This is consistent with observations reported in previous AEMP years, as summarized in the *2017 to 2019 Aquatic Effects Re-evaluation Report* (Golder 2020b) and subsequent AEMP annual reports (Golder 2018, 2019b, 2020a).

[2] This is consistent with observations reported in the 2018 and 2019 AEMP, annual reports (Golder 2019b, 2020a).

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8 CLOSURE

We trust the information in this report meets your requirements at this time. If you have any questions relating to the information contained in this report, please do not hesitate to contact the undersigned.

GOLDER ASSOCIATES LTD.

Report prepared by:	Report reviewed by:
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ATTACHMENT A

PHYTOPLANKTON TAXONOMIST COMPARISON

INTRODUCTION

Following completion of the 2020 phytoplankton sample collection, Diavik Diamond Mines (2012) Inc. (DDMI) was informed that the phytoplankton taxonomist selected for the Aquatic Effects Monitoring Program (AEMP; Advanced Eco-Solutions Inc., Liberty Lake, Washington, US) would not be able to analyze the samples in 2020 or moving forward. To analyze samples in a timely manner and allow reporting of results in the 2020 AEMP Annual report, DDMI contracted a new taxonomist to complete the analysis (Biologica Environmental Services, Ltd., Victoria British Columbia [BC], Canada, [Biological]). Biologica is a full-service, high-capacity aquatic taxonomy laboratory with an established reputation for the highest standards of accuracy, consistency, and efficiency. Biologica has been providing marine taxonomic services for government and industry for over 20 years. In 2012, Biologica, diversified and strengthened its core services, expanding them to include freshwater phytoplankton.

As described in the *Quality Assurance Project Plan Version 3.1* (QAPP; Golder 2017), per the WLWB (2016) directive, if a laboratory or taxonomist change is proposed, a Special Study would be conducted in advance of the change. The main objective of the Special Study is to describe differences in methods, if any, used by the previous and new laboratory or taxonomist, and evaluate differences between laboratories or taxonomists based on split samples. Given the lack of advance notice given by the previous taxonomist, this document represents the Special Study required by the QAPP, and is based on five samples that were collected in 2017.

The phytoplankton taxonomist comparison evaluated taxonomic identifications provided by Eco-Logic Ltd. (Eco-logic), Vancouver, British Columbia (BC) and Biologica. In 2017, Eco-logic analyzed the samples but following analysis, the taxonomist retired. The taxonomist at Advanced Eco-Solutions was trained as an employee by the taxonomist of Eco-Logic. Because the same methods were employed by both taxonomists and the taxonomist from Eco-Logic trained the taxonomist at Advanced Eco-Solutions, it was concluded that data from the two taxonomists would be comparable. Samples collected in 2017 were retained by DDMI for follow-up if needed, prior to submission of the *2017 to 2019 Aquatic Effects Re-evaluation Report* (Golder 2020); however, 2018 and 2019 samples were disposed by the taxonomist, despite instructions to ship samples back to DDMI. Therefore, the taxonomist comparison was based on a subset of the 2017 AEMP phytoplankton samples, rather than more recent split samples.

The 2020 phytoplankton taxonomist comparison examined differences in the taxonomic identifications between the two taxonomists for the 2017 phytoplankton samples, as well as differences in abundance and biomass estimates provided by each.

METHODS

Station Selection for Taxonomist Comparison

A subset of the 2017 phytoplankton samples consisting of samples from five stations were used for the taxonomist comparison. These samples were originally analyzed by Eco-logic. The unanalyzed portion of these samples were sent to Biologica for a second taxonomic analysis in 2020. The selection of stations to include in the comparison was based on exposure to the Mine effluent, and consisted of a near-field (NF) area station (i.e., NF3), one station each along the MF1 and MF2 transects (i.e., MF1-3 and FF2-2, respectively), and two stations along the MF3 transect (i.e., MF3-3 and MF3-7). These stations were selected to represent a wide range in exposure to the Mine effluent, as allowed by the stations sampled during an interim monitoring year.

Taxonomic Identifications

Biologica was provided with the methods statement by Eco-logic and asked to follow the procedures as closely as possible. The methods included taking small aliquots of the preserved phytoplankton samples and allowing them to settle in sedimentation chambers following the procedure of Lund et al. (1958). Eco-Logic took 25-mL aliquots, while Biologica took 10 to 25-mL aliquots. Eco-logic allowed cells to settle for a minimum of 4 hours, while Biologica allowed cells to settle for a minimum of 24 hrs. Differences in the aliquots taken were accounted for in the abundance and biovolume calculations, but the difference in settling time may have caused inconsistencies in the number and variety of species encountered in the samples.

Algal units were counted from randomly selected transects on Carl Zeiss inverted phase-contrast microscopes at high and low power. High power magnification was used for the majority of the analysis. The lower power scans were performed to confirm a uniform settling of the sample on the bottom of the plate and to evaluate the occurrence of rare species (Utermöhl 1958). Counting units were individual cells, filaments, or colonies, depending on the organization of the algae. A minimum of 250 and a maximum of 300 cells or counting units were enumerated in each sample for statistical accuracy (Lund et al. 1958).

Both Eco-logic and Biologica identified phytoplankton taxa to the genus level, reported abundance as cells per litre (cells/L), and calculated wet weight biomass from abundance and specific biovolume estimates based on geometric solids (Rott 1981), by assuming unit-specific gravity. The biovolume, in units of cubic millimetres per cubic metre (mm^3/m^3) wet weight of each species, was estimated from the average dimensions of 10 to 15 individuals. The biovolumes of colonial taxa were based on the number of individuals within each colony.

Taxonomic identifications by Eco-logic were based primarily on Prescott (1982), Canter-Lund and Lund (1995), and Wehr and Sheath (2003). Taxonomic identifications by Biologica were based primarily on Cox (1996), Krammer and Lange-Bertalot (1986, 1988, 1991a, 1991b), Hillebrand et al. (1999), Kelly (2000), Komárek (2000), Komárek and Anagnostidis (2000a,b), John et al. (2002), Taylor et al. (2007), Wehr et al. (2015), Guiry and Guiry (2017), and Spaulding and Edlund (2020).

Data Analysis

Qualitative analysis of the total abundance, biomass, and taxonomic richness were performed. In addition, group dominance rankings and overall community composition were investigated. The following methods were used to summarize the data:

- Total abundance and biomass were calculated separately for each sample and compared between taxonomists.
- The number of taxa was compared between taxonomists.
- Abundance and biomass data were divided into the seven major taxonomic groups present in the 2017 samples: Cyanobacteria, Chlorophyceae (chlorophytes), Chrysophyceae (chrysophytes), Cryptophyceae (Cryptophytes), Bacillariophyceae (diatoms), Dinophyceae (dinoflagellates), and Euglenophyceae (euglenophytes), and relative abundance and biomass were compared between taxonomists.
- Major taxonomic group dominance rankings and taxonomic dominance rankings were calculated and compared between taxonomists.

Total abundance and biomass were compared based on the relative percent difference (RPD), calculated using the following formula:

RPD = (|difference in abundance or biomass between duplicate samples|/mean abundance or biomass) x100

The Bray-Curtis dissimilarity index, which is a measure of ecological distance between two communities, was used to assess the overall similarity between the datasets produced by each taxonomist for each sample. The value of the Bray-Curtis dissimilarity index ranges from zero (identical communities) to one (very dissimilar communities) and is calculated using the following formula:

$$b = \frac{\sum_{k=1}^{n} \left| x_{ik} - x_{jk} \right|}{\sum_{k=1}^{n} \left(x_{ik} + x_{jk} \right)}$$

In this formula, *b* is the Bray-Curtis dissimilarity index, *n* is the number of taxa in the sample, x_{ik} and x_{jk} are abundance or biomass of taxon *(i)* in the original *(j)* and re-counted *(k)* samples, respectively. Bray-Curtis comparisons were performed on data grouped at the major ecological group level for the phytoplankton community (i.e., diatoms, chlorophytes, microflagellates, cyanobacteria, and dinoflagellates). Index values greater than 0.5 indicate high dissimilarity.

RESULTS

Comparisons of Abundance and Biomass

Total phytoplankton abundance and abundances of microflagellates and chlorophytes had RPD values below 50%, or just above 50%, for most of the five stations selected for the taxonomist comparison. Average RPDs for these variables were 32%, 54% and 30%, respectively (Table A-1, Figure A-1). On average, microflagellates and chlorophytes accounted for the majority of the total abundance in the samples analyzed by both Eco-logic (average: 77%) and Biologica (average: 73%). Larger differences in abundance were observed between the two taxonomists for diatoms (average RPD: 161%), cyanobacteria (average RPD: 185%) and dinoflagellates (average RPD: 150%) (Table A-1, Figure A-1). These results suggest that although there were notable differences in reported abundances by the two taxonomists for some major phytoplankton groups, the data for total phytoplankton abundance and abundances of two major groups that account for a large proportion of total abundance are comparable.

Total phytoplankton biomass and biomass of microflagellates and diatoms had larger RPD values than abundance variables, except for total biomass, which had an average RPD of 35% (Table A-2). Microflagellate and diatom biomass had lower RPD values (i.e., 58% and 79%, respectively) than the other groups (i.e., 90% to 193%), but average RPDs were above 50% for all major taxa. Microflagellates and diatoms accounted for the majority of total biomass in samples analyzed by both Eco-logic (average: 81%) and Biologica (average: 72%). Larger differences in biomass were observed between the two taxonomists for chlorophytes (average RPD: 90%), cyanobacteria (average RPD: 193%) and dinoflagellates (average RPD: 193%) (Table A-2, Figure a-2). These results show greater variability between taxonomists for major groups than the abundance data, but also suggest that although there were notable differences in reported biomass by the two taxonomists, the data for total phytoplankton biomass and biomass of two major groups that account for a large proportion of total biomass are generally comparable.

Table A-1 Phytoplankton Abundance and Abundance of Major Ecological Groups, Arranged by Taxonomist

Area	Station	Major Taxonomic Group	Total Abundance (cells/L)		RPD (%)	Bray Curtis Dissimilarity Index
			Eco-logic	Biologica		
NF	NF3	Microflagellates	1,926,010	2,612,406	30	0.24
		Diatoms	375,065	56,266	**148**	
		Chlorophytes	395,339	211,629	**61**	
		Cyanobacteria	30,411	865,833	**186**	
		Dinoflagellates	10,137	32,312	**104**	
		Total abundance	2,736,962	3,778,447	32	
MF1	MF1-3	Microflagellates	729,857	1,414,977	**64**	0.31
		Diatoms	283,833	21,435	**172**	
		Chlorophytes	243,286	345,437	35	
		Cyanobacteria	20,274	264,576	**172**	
		Dinoflagellates	-	11,357	**200**	
		Total abundance	1,277,249	2,057,782	47	
MF2	FF2-2	Microflagellates	993,416	1,721,076	**54**	0.26
		Diatoms	709,583	42,910	**177**	
		Chlorophytes	243,286	235,584	3	
		Cyanobacteria	40,548	476,924	**169**	
		Dinoflagellates	20,274	-	**200**	
		Total abundance	2,007,105	2,476,494	21	
MF3	MF3-3	Microflagellates	1,926,010	845,743	**78**	0.33
		Diatoms	233,149	59,412	**119**	
		Chlorophytes	334,518	223,867	40	
		Cyanobacteria	-	236,202	**200**	
		Dinoflagellates	20,274	31,933	45	
		Total abundance	2,513,950	1,397,157	**57**	
MF3	MF3-7	Microflagellates	1,013,690	660,906	42	0.14
		Diatoms	446,023	14,925	**187**	
		Chlorophytes	212,875	190,612	11	
		Cyanobacteria	-	815,713	**200**	
		Dinoflagellates	-	36,445	**200**	
		Total abundance	1,672,588	1,718,601	3	
Average % of Total Abundance and Average RPD Values		Microflagellates	63%	61%	**54**	-
		Diatoms	21%	2%	**161**	
		Chlorophytes	14%	12%	30	
		Cyanobacteria	1%	24%	**185**	
		Dinoflagellates	0%	1%	**150**	
		Total abundance	-	-	32	

Note: **Bolded** values indicate RPD values greater than 50%.

- = no data or not applicable; cells/L = cells per litre; RPD = relative percent difference; NF = near-field; MF = mid-field; FF = far-field.

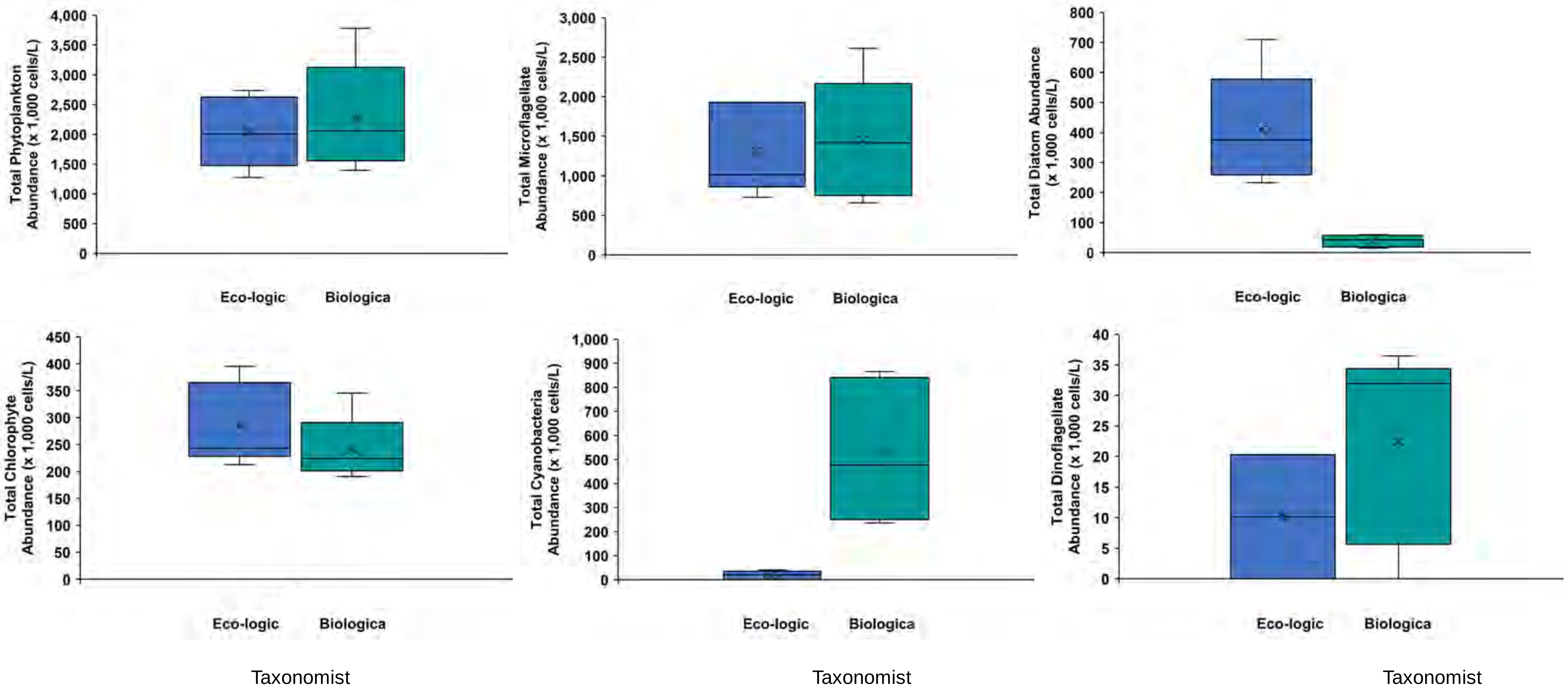
Table A-2 Phytoplankton Biomass and Biomass of Major Ecological Groups, Arranged by Taxonomist

Area	Station	Major Taxonomic Group	Total Biomass (mg/m^3)		RPD (%)	Bray Curtis Dissimilarity Index
			Eco-logic	Biologica		
NF	NF3	Microflagellates	279	365	27	0.27
		Diatoms	119	118	1	
		Chlorophytes	112	14	**154**	
		Cyanobacteria	0.3	5.9	**180**	
		Dinoflagellates	5	253	**192**	
		Total biomass	516	757	38	
MF1	MF1-3	Microflagellates	84	248	**99**	0.45
		Diatoms	30	55	**57**	
		Chlorophytes	39	23	**52**	
		Cyanobacteria	0.4	22	**193**	
		Dinoflagellates	-	61	**200**	
		Total biomass	153	408	**91**	
MF2	FF2-2	Microflagellates	140	274	**65**	0.27
		Diatoms	249	77	**105**	
		Chlorophytes	75	16	**128**	
		Cyanobacteria	0.4	28	**194**	
		Dinoflagellates	9	-	**200**	
		Total biomass	472	396	18	
MF3	MF3-3	Microflagellates	366	155	**81**	0.26
		Diatoms	26	102	**119**	
		Chlorophytes	54	31	**53**	
		Cyanobacteria	-	1	**200**	
		Dinoflagellates	10	153	**175**	
		Total biomass	455	443	3	
MF3	MF3-7	Microflagellates	131	154	16	0.19
		Diatoms	129	35	**115**	
		Chlorophytes	46	24	**62**	
		Cyanobacteria	-	5	**200**	
		Dinoflagellates	-	22	**200**	
		Total biomass	307	241	24	
Average % of Total Abundance and Average RPD Values		Microflagellates	52%	55%	**58**	-
		Diatoms	29%	17%	**79**	
		Chlorophytes	18%	6%	**90**	
		Cyanobacteria	0%	3%	**193**	
		Dinoflagellates	1%	18%	**193**	
		Total biomass	-	-	35	

Note: **Bolded** values indicate RPD values greater than 50%.

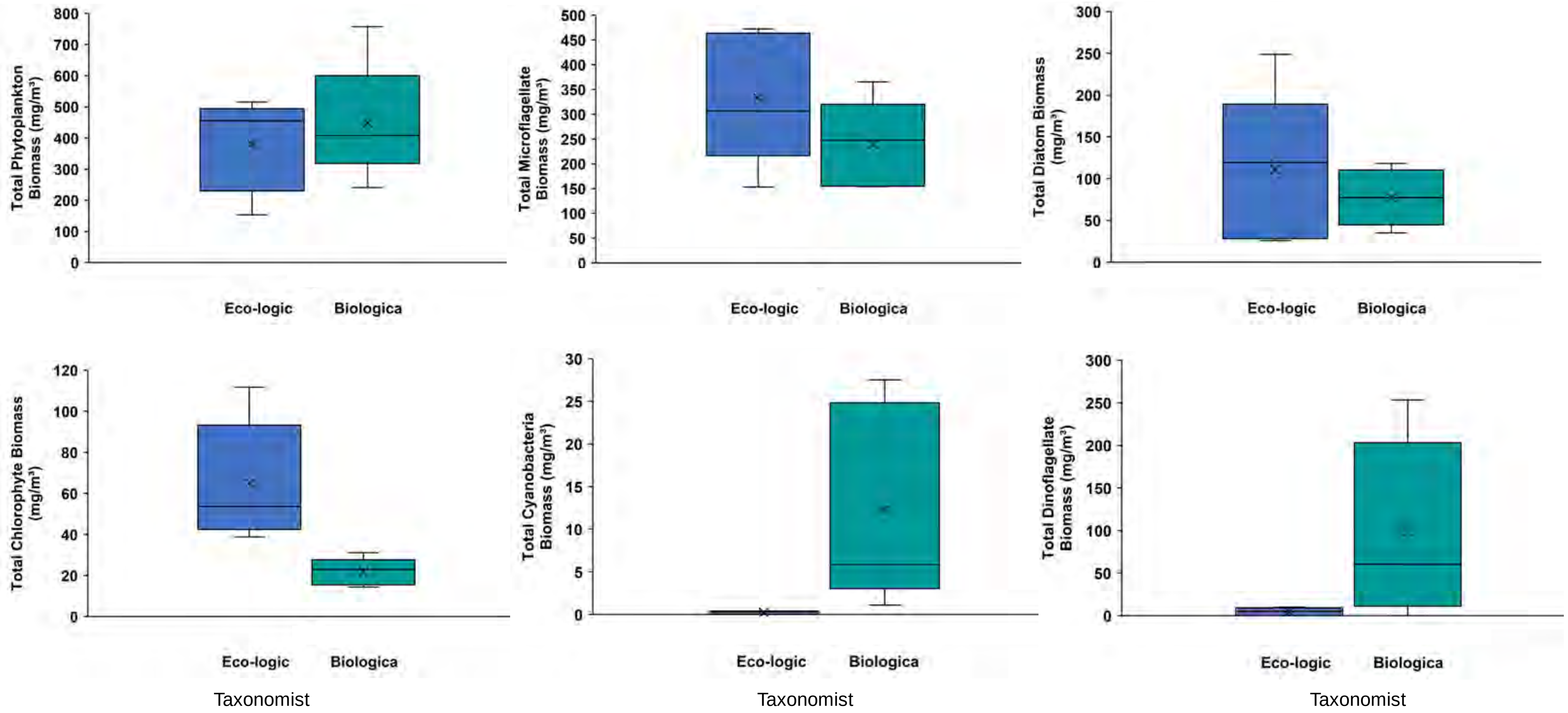
mg/m^3 = milligrams per cubic metre; - = no data or not applicable; RPD = relative percent difference; NF = near-field; MF = mid-field; FF = far-field.

Figure A-1 Total Phytoplankton Abundance and Abundance of Major Ecological Groups, Arranged by Taxonomist



cells/L = cells per litre.

Figure A-2 **Total Phytoplankton Biomass and Biomass of Major Ecological Groups, Arranged by Taxonomist**



mg/m³ = milligrams per cubic metre.

Comparison of Taxonomic Richness

The number of genera identified within each major group differed between Eco-logic and Biologica (Tables A-3 and A-4, Figure A-3). Eco-logic identified fewer genera (29 taxa) compared to Biologica (52 taxa), with 17 taxa in common. On average, Biologica identified 12 more taxa compared to Eco-logic based on the five stations selected for the taxonomist comparison, and an average RPD of 50% (Table A-3). Biologica identified more cyanobacteria taxa compared to Eco-logic, while for the other major groups, a similar number of taxa were identified by both taxonomists, although estimates were slightly higher for Biologica. Differences between the taxonomists were also observed in taxonomic dominance based on genus-level identifications (Table A-5). In the Eco-logic dataset the dominant taxon was the microflagellate, *Ochromona*s sp., while in the Biologica dataset, the dominant taxon was the microflagellate, *Uroglena* sp. In the Eco-logic dataset, *Uroglena* sp. was not present.

These results suggest that notable differences in taxonomic richness were reported by the two taxonomists. It is recommended that either richness be dropped from the Action Level evaluation for phytoplankton, or the normal range for phytoplankton richness be adjusted to reflect the difference between taxonomists, by shifting it upwards by the average difference between taxonomists based on the five sets of sample results (i.e., 12 taxa).

Table A-3 Differences in Genus-level Phytoplankton Richness between Taxonomists

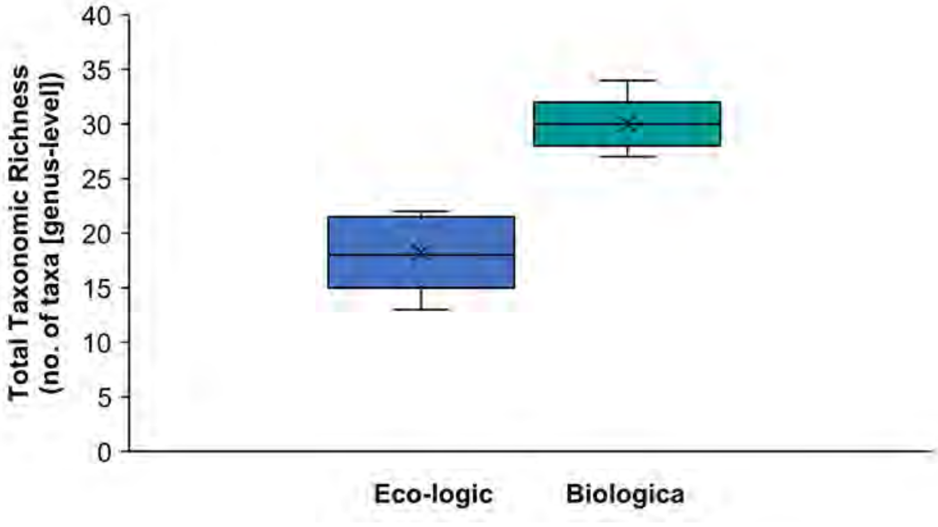
Station/Sample	Eco-logic (number of genera)	Biologica (number of genera)	Difference	
			Number of Genera Relative to Eco-logic	RPD (%)
NF3	22	30	+8	31
MF1-3	17	27	+10	45
FF2-2	18	30	+12	50
MF3-3	21	34	+13	47
MF-3-7	13	29	+16	76
Average	-	-	**+12**	**50**

- = no data or not applicable; RPD = relative percent difference; NF = near-field; MF = mid-field; FF = far-field.

Table A-4 Number of Taxa Identified by Taxonomist at the Genus Level, Arranged by Major Group

Major Group	Number of Taxa Identified		Taxa in Common	Group Dominance Ranking (based on abundance)		Group Dominance Ranking (based on biomass)	
	Eco-logic	Biologica		Eco-logic	Biologica	Eco-logic	Biologica
Total microflagellates	6	11	2	1	1	1	1
Total diatoms	5	9	4	2	4	2	3
Total cyanobacteria	2	11	1	4	2	5	5
Total chlorophytes	14	18	8	3	3	3	4
Total dinoflagellates	2	3	2	5	5	4	2
Total phytoplankton taxa	29	52	17	-	-	-	-

Figure A-3 Total Phytoplankton Taxonomic Richness at the Genus Level, Arranged by Taxonomist



no. = number.

Table A-5 Dominant Phytoplankton Taxa by Biomass

Major Taxonomic Group	Genera	Eco-Logic			Biologica		
		Mean Biomass (mg/m^3)	Proportion (%)	Dominance Ranking	Mean Biomass (mg/m^3)	Proportion (%)	Dominance Ranking
Microflagellates	*Ochromonas* sp.	101	26	1	(0)	(0)	-
	Uroglena sp.	(0)	(0)	-	99	26	1
Diatoms	*Tabellaria* sp.	86	23	2	50	13	5
Microflagellates	*Plagioselmis* sp.	(0)	(0)	-	73	19	2
	Dinobryon sp.	61	16	3	55	14	4
Dinoflagellates	*Gymnodinium* sp.	(4)	(1)	-	59	15	3
Chlorophytes	*Monoraphidium* sp.	25	6	4	(5)	(1)	-
Dinoflagellates	*Peridinium* sp.	(<1)	(0)	-	39	10	6
Microflagellates	*Cyptomonas* sp.	18	5	5	(5)	(1)	-
Diatoms	*Asterionella* sp.	(14)	(4)	-	24	6	7

Note: Dominant taxa were identified as taxa present in proportions greater than 5% of total biomass. Numbers in parentheses are for non-dominant taxa.

mg/m^3 = milligrams per cubic metre; - = no data or not applicable.

Comparison of Community Composition

Despite the differences in reported abundance and biomass estimates by the two taxonomists, the Bray-Curtis index values for phytoplankton abundance and biomass were below 0.50, ranging from 0.14 to 0.45 (Tables A-1 and A-2), indicating generally comparable community composition reflected by the datasets produced by the two taxonomists.

The dominant major taxonomic group for both abundance and biomass was the same for both taxonomists (i.e., microflagellates); however, the sub-dominant groups differed between taxonomists (Table A-1, Figures A-4 and A-5). Based on the mean of the subset of the 2017 data, Eco-logic results show that the community was dominated by microflagellates, followed by chlorophytes and diatoms, cyanobacteria and dinoflagellates based on abundance, while Biologica results showed that the community was dominated by microflagellates, followed by cyanobacteria, chlorophytes, diatoms, and dinoflagellates (Figure A-4). Based on biomass, the Eco-logic dataset showed that the community was dominated by microflagellates, followed by diatoms, chlorophytes, dinoflagellates, and cyanobacteria, while the Biologica dataset showed that the community was dominated by microflagellates, followed by dinoflagellates, diatoms, chlorophytes, and cyanobacteria (Table A-2, Figure A-5).

Figure A-4 **Relative Phytoplankton Abundance at Each Station and Grouped by Taxonomist, 2020**

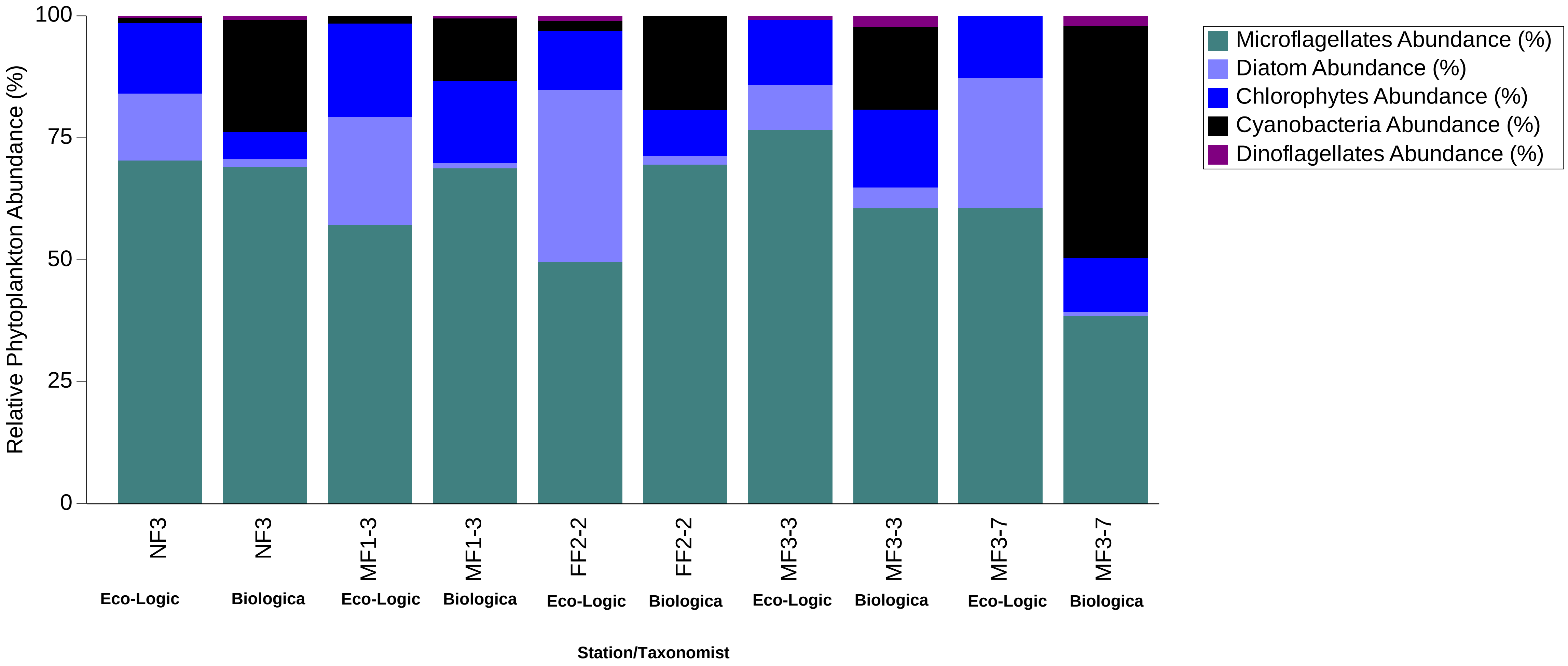
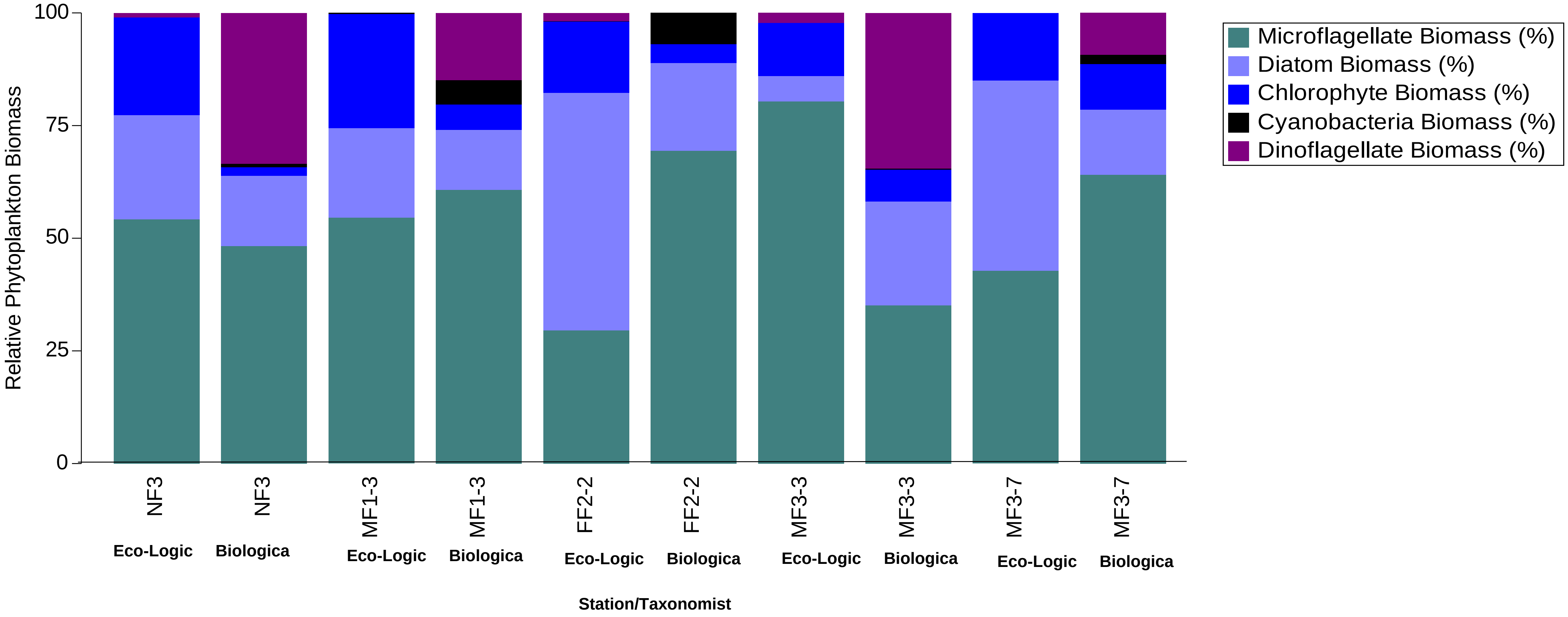


Figure A-5 **Relative Phytoplankton Biomass at Each Station and Grouped by Taxonomist, 2020**



SUMMARY

Results of the phytoplankton taxonomist comparison using a subset of the 2017 AEMP samples can be summarized as follows:

- Although there were notable differences in reported abundances and biomass by the two taxonomists for some major phytoplankton groups, the data for total phytoplankton abundance and biomass, and for two major groups (abundance: microflagellates and chlorophytes; biomass: microflagellates and diatoms) that account for a large proportion of total abundance and biomass, are comparable.
- Bray-Curtis index values comparing phytoplankton abundance and biomass between taxonomists were in the acceptable range, indicating generally comparable community composition reflected by the datasets produced by the two taxonomists.
- On average, Biologica identified 12 more taxa (genera) compared to Eco-logic based on the dataset for the five stations selected for the taxonomist comparison. Biologica identified more cyanobacteria taxa compared to Eco-logic, while for the other major groups, a similar number of taxa were identified by both taxonomists, although estimates were slightly higher for Biologica.
- The dominant major taxonomic group for both abundance and biomass was the same for both taxonomists (i.e., microflagellates); however, the sub-dominant groups differed between taxonomists. Differences between the taxonomists were also observed in taxonomic dominance based on genus-level identifications.

The results of the taxonomist comparison highlight the importance of retaining the same taxonomist for an entire monitoring program; however, as demonstrated during this AEMP, that is frequently not possible. Phytoplankton taxonomy data typically display acceptable internal consistency when evaluated based on a dataset produced by the same taxonomist (see Attachment B), and allow within year-evaluation of effects with an appropriate level of sensitivity. Therefore, the taxonomist differences described in this attachment are of limited concern regarding the evaluation of effects during the 2020 AEMP (e.g., using gradient analysis and visual comparisons of community composition), but comparisons to normal ranges and reference conditions, and evaluation of temporal trends in re-evaluation reports, can present difficulties following a switch to a different taxonomist.

The results of comparisons described in this attachment show that total phytoplankton abundance and biomass, and abundance and biomass of the dominant phytoplankton group (microflagellates), are generally similar between datasets produced by the two taxonomists; therefore, these variables can be compared to normal ranges that were adjusted during previous data analyses to match the data produced by Eco-Logic. Comparing richness, and abundances and biomass of other groups to normal ranges is less likely to produce reliable results, given the greater observed differences between taxonomists for those variables. Although comparison to normal ranges for most major groups may no longer be accurate, the ability to detect Mine-related effects is not compromised, because those effects are best detected using gradient analysis, and overall level of productivity can still be evaluated based on comparison of total phytoplankton biomass to the normal range.

During annual AEMP data analysis, Action Level exceedances are evaluated by comparisons of total biomass and richness to the reference condition dataset. As described above, the switch in taxonomist does not negatively influence the Action Level evaluation for total phytoplankton. However, given that Biologica identified a greater number of genera than Eco-logic, comparison of the 2020 richness data to normal ranges reflecting taxonomy by Eco-Logic would not yield realistic results, and would be less likely to result in an Action Level trigger compared to previous years. To remedy this situation, it is recommended that either richness be dropped from the Action Level evaluation for phytoplankton, or the normal range for phytoplankton richness be adjusted to reflect the difference between taxonomists, by shifting it upwards by the average difference between taxonomists based on the five sets of sample results (i.e., by 12 taxa). Given that the taxonomist comparison was done based on a limited set of samples and did not include areas of Lac de Gras least affected by the effluent (FFA and FFB), the recommendation to adjust the normal range for richness is subject to verification of the difference between taxonomists in the FFA and FFB areas using previous results from Eco-Logic and Biologica results from the next comprehensive year monitoring.

It is also recommended that normal range comparisons for individual groups should be discontinued. This reduction will not impact the annual assessment of effects or the Action Level assessment because as discussed, the Action Level assessment is based on total phytoplankton biomass and not biomass of major groups.

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ATTACHMENT B

QUALITY ASSURANCE AND QUALITY CONTROL

QUALITY ASSURANCE AND QUALITY CONTROL

Introduction

Quality assurance and quality control (QA/QC) practices determine data integrity and are relevant to all aspects of a study, from sample collection to data analysis and reporting, and are described for the Mine AEMP in the *Quality Assurance Project Plan Version 3.1* (Golder 2017). Quality assurance (QA) encompasses management and technical practices designed to generate data of appropriate quality. Quality control (QC) is an aspect of QA and includes the techniques used to assess data quality and the corrective actions to be taken when the data quality objectives are not met. This appendix describes QA/QC practices applied during the 2020 plankton component of the Aquatic Effects Monitoring Program (AEMP), evaluates QC data, and describes the implications of QC results to the interpretation of study results.

Quality Assurance

Field Staff Training and Operations

Diavik Diamond Mines (2012) Inc. (DDMI) field staff are trained to be proficient in standardized field sampling procedures, data recording, and equipment operations applicable to water quality sampling. Field work was completed according to specific instructions to field crews and Standard Operating Procedures (SOPs). The procedures are described in:

- ENVI-923-0119 “AEMP SOP Combined Open Water and Ice Cover”
- ENVI-902-0119 “Laboratory Quality Assurance/Quality Control”
- ENVI-900-0119 “Chain of Custody”

These SOPs include guidelines for field record-keeping and sample tracking, guidance for use of sampling equipment, sampling procedures, and sample labelling, shipping and tracking protocols.

Office Operations

A data management system was in place to facilitate an organized system of data control, analysis, and filing. Relevant elements of this system are as follows:

- pre-field meetings to discuss specific work instructions with field crews
- field crew check-in with task managers every 24 to 48 hours to report work completed during that period
- designating two crew members responsible for:
    - collecting all required samples
    - immediate download and storage of electronic data
    - completing chain-of-custody and analytical request forms; labelling and documentation
    - processing, where required, and delivering samples to analytical laboratory in a timely manner

- cross-checking chain-of-custody forms and analysis request forms by the task manager to verify that the correct analysis packages had been requested
- review of field sheets by the task manager for completeness and accuracy
- reviewing taxonomy data immediately after receipt from the taxonomist
- creating backup files before data analysis
- completing appropriate logic checks for accuracy of calculations

Quality Control

Methods

Quality control is a specific aspect of QA that includes the techniques used to assess data quality. The field QC program consisted of the collection of duplicate samples to assess within-station variation and sampling precision. Duplicate samples consisted of two samples collected from the same station at the same time, using the same sampling and sample handling procedures. They were labelled and preserved individually and were submitted separately to the taxonomist for identical analyses. In 2020, duplicate zooplankton samples were collected from each station and submitted to Salki Consultants Inc. for analysis of taxonomic composition. Duplicate phytoplankton samples were not collected in 2020 as a result of a field crew oversight, which is a deviation from the *Quality Assurance Project Plan Version 3.1* (QAPP; Golder 2017). The zooplankton and phytoplankton laboratory QC program consisted of four split samples which were analyzed by the same taxonomist to verify counting precision. The data were entered into electronic format by the taxonomist and were double-checked by the same taxonomist upon entry; errors were corrected as necessary before transferring the electronic files to DDMI.

Initial screening of the 2020 AEMP dataset was completed using the method specified in the QAPP (Golder 2017). If anomalies were identified during the screening process, the data were plotted with the corresponding 2007 to 2019 data for a range comparison. If the data were also outside the corresponding 2007 to 2019 range, laboratory re-analysis was requested. If laboratory re-analysis confirmed the results, the anomalous values were retained in the final dataset, unless there was a technically defensible reason to exclude them.

The inherent variability associated with the plankton samples makes the establishment of a QC threshold value difficult. For the purposes of the plankton QC, samples were flagged and assessed further if there was a greater than 50% difference, calculated as the relative percent difference (RPD), in total abundance or total biomass between the original and duplicate samples. Similarly, samples were flagged and assessed further if there was a greater than 50% difference in total abundance or biomass between the taxonomist's split samples.

The RPD was calculated using the following formula:

$$RPD = (|\text{difference in abundance or biomass between duplicate samples}|/\text{mean abundance or biomass})\times 100$$

In addition, the Bray-Curtis dissimilarity index, which is a measure of ecological distance between two communities, was used to assess the overall similarity between the taxonomist's split samples. The value of the Bray-Curtis dissimilarity index ranges from zero (identical communities) to one (very dissimilar communities) and is calculated using the following formula:

$$b = \frac{\sum_{k=1}^{n} \left| x_{ik} - x_{jk} \right|}{\sum_{k=1}^{n} \left(x_{ik} + x_{jk} \right)}$$

In this formula, *b* is the Bray-Curtis dissimilarity index, *n* is the number of taxa in the sample, x_{ik} and x_{jk} are abundance or biomass of taxon *(i)* in the original *(j)* and re-counted *(k)* samples, respectively. Bray-Curtis comparisons were performed on data grouped at the major ecological group level for the phytoplankton community (i.e., diatoms, chlorophytes, microflagellates, cyanobacteria, and dinoflagellates) and zooplankton community (i.e., cladocerans, cyclopoids, calanoids, and rotifers). Index values greater than 0.5 were flagged and follow-up discussions with the taxonomist were initiated.

Duplicate data were not automatically rejected because of an exceedance of the acceptance criterion; rather, they were evaluated on a case-by-case basis, because some level of within-station variability is expected for duplicate samples. If there were departures from the acceptance criterion, the samples were flagged, and a variety of follow-up assessments were performed. These assessments included plotting the data for visual identification of anomalous data. If there were values that were visually anomalous, the data were plotted with the corresponding 2007 to 2019 data for a range comparison. If the data were outside the corresponding 2007 to 2019 range, laboratory re-analysis was requested. If laboratory re-analysis confirmed the results, the anomalous values were retained in the final dataset, unless there was a technically defensible reason to exclude them.

Results

Duplicate Samples

Phytoplankton field QC duplicate samples were not collected in 2020 as a result of a field crew oversight, which is a deviation from the *Quality Assurance Project Plan Version 3.1* (Golder 2017).

Several stations had RPDs that exceeded 50% for one or more of the dominant groups for zooplankton abundance: NF1, NF3, MF1-5, MF2-1, MF2-3, FF2-2, MF3-1, MF3-2, MF3-3, MF3-4, MF3-5, FF1-2, and FFD-1 (Table B-1). However, only two samples had RPDs greater than 50% for total zooplankton abundance: MF2-1 and MF3-2. Despite these exceedances, the overall sample dissimilarity did not exceed the acceptance criterion (i.e., none of the samples had Bray-Curtis dissimilarity values greater than 0.5). Comparison of duplicate zooplankton samples for total abundance and the abundances of the dominant groups indicated an overall similarity between duplicate samples based on the Bray-Curtis dissimilarity index (Table B-1). Therefore, the duplicate zooplankton abundance samples were deemed acceptable for the purposes of this study.

All stations, except MF3-5, MF3-6, and MF3-7 had RPDs that exceeded 50% for one or more of the dominant groups for zooplankton biomass (Table B-2). Four stations had exceedances based on total biomass: MF2-1, MF2-3, MF3-2, and MF3-3. Despite these exceedances, the overall sample dissimilarity did not exceed the acceptance criterion (i.e., none of the samples had Bray-Curtis dissimilarity values greater than 0.5). Comparison of duplicate zooplankton samples for total biomass and biomass of the dominant groups indicated an overall similarity between duplicate samples based on the Bray-Curtis dissimilarity index (Table B-2). Therefore, the duplicate zooplankton biomass samples were deemed acceptable for the purposes of this study.

Table B-1 **Results for Field QC (Duplicate) Zooplankton Abundance Samples Collected from Lac de Gras and Lac du Sauvage, 2020**

Area	Station	Major Taxonomic Group	Total Abundance (Ind/L)		RPD (%)	Bray Curtis Dissimilarity Index
			Original Sample	Duplicate Sample		
NF	NF1	Calanoida	4.39	3.84	13.51	0.09
		Cyclopoida	9.06	11.32	22.22	
		Cladocera	0.06	0.02	**88.41**	
		Rotifera	30.46	36.35	17.63	
		Total abundance	43.97	51.53	15.83	
	NF2	Calanoida	2.61	3.36	25.32	0.11
		Cyclopoida	7.93	8.73	9.60	
		Cladocera	0.04	0.03	22.47	
		Rotifera	32.38	23.67	31.11	
		Total abundance	42.96	35.79	18.21	
	NF3	Calanoida	5.35	2.84	**61.22**	0.14
		Cyclopoida	11.58	9.82	16.39	
		Cladocera	0.13	0.01	**179.89**	
		Rotifera	39.00	29.44	27.94	
		Total abundance	56.06	42.11	28.42	
	NF4	Calanoida	7.49	4.78	44.20	0.15
		Cyclopoida	8.35	6.81	20.34	
		Cladocera	0.11	0.07	43.27	
		Rotifera	27.18	41.48	41.67	
		Total abundance	43.12	53.14	20.80	
	NF5	Calanoida	6.20	3.87	46.24	0.11
		Cyclopoida	8.23	8.16	0.88	
		Cladocera	0.04	0.04	3.15	
		Rotifers	32.30	25.36	24.06	
		Total abundance	46.77	37.43	22.18	
MF1	MF1-1	Calanoida	8.71	8.11	7.17	0.02
		Cyclopoida	13.99	13.88	0.77	
		Cladocera	0.04	0.04	1.92	
		Rotifera	37.30	39.43	5.56	
		Total abundance	60.04	61.47	2.34	
	MF1-3	Calanoida	8.26	6.68	21.25	0.08
		Cyclopoida	11.34	11.44	0.91	
		Cladocera	0.02	0.01	48.28	
		Rotifers	57.45	48.15	17.61	
		Total abundance	77.07	66.28	15.05	
	MF1-5	Calanoida	3.23	1.97	48.61	0.22
		Cyclopoida	53.30	34.23	43.56	
		Cladocera	0.18	0.01	**169.55**	
		Rotifera	20.02	12.83	43.77	
		Total abundance	76.72	49.04	44.02	
MF2	MF2-1	Calanoida	3.78	5.96	44.58	0.26
		Cyclopoida	8.15	9.07	10.63	
		Cladocera	0.04	0.09	**79.07**	
		Rotifera	19.85	39.03	**65.15**	
		Total abundance	31.83	54.14	**51.92**	
	MF2-3	Calanoida	3.88	7.61	**64.89**	0.14
		Cyclopoida	8.18	10.45	24.47	
		Cladocera	0.04	0.16	**120.70**	
		Rotifera	35.90	44.95	22.41	
		Total abundance	47.99	63.19	27.33	
	FF2-2	Calanoida	4.02	7.70	**62.86**	0.13
		Cyclopoida	5.65	7.40	26.82	
		Cladocera	0.17	0.25	38.92	
		Rotifera	28.13	18.83	39.59	
		Total abundance	37.96	34.18	10.49	
	FF2-5	Calanoida	4.13	6.26	40.89	0.19
		Cyclopoida	5.98	6.97	15.21	
		Cladocera	0.04	0.04	21.80	
		Rotifera	10.61	17.28	47.86	
		Total abundance	20.76	30.55	38.17	
MF3	MF3-1	Calanoida	1.76	1.65	6.53	0.18
		Cyclopoida	15.09	17.33	13.83	
		Cladocera	0.14	0.04	**113.18**	
		Rotifera	15.51	27.06	**54.26**	
		Total abundance	32.50	46.08	34.57	
	MF3-2	Calanoida	2.35	1.28	**58.66**	0.33
		Cyclopoida	17.43	7.91	**75.08**	
		Cladocera	0.03	0.02	**50.75**	
		Rotifera	14.30	7.99	**56.68**	
		Total abundance	34.11	17.20	**65.90**	
	MF3-3	Calanoida	3.00	1.75	**52.74**	0.13
		Cyclopoida	15.99	9.92	46.88	
		Cladocera	0.03	0.05	**63.69**	
		Rotifera	16.52	15.59	5.81	
		Total abundance	35.54	27.30	26.21	
	MF3-4	Calanoida	2.31	4.46	**63.56**	0.11
		Cyclopoida	12.24	13.56	10.26	
		Cladocera	0.10	0.15	43.05	
		Rotifera	18.78	23.71	23.20	
		Total abundance	33.42	41.88	22.46	
MF3	MF3-5	Calanoida	2.57	2.87	11.11	0.07
		Cyclopoida	8.53	11.37	28.53	
		Cladocera	0.09	0.05	**53.59**	
		Rotifera	26.95	29.67	9.60	
		Total abundance	38.14	43.96	14.17	
	MF3-6	Calanoida	1.69	2.09	21.09	0.04
		Cyclopoida	16.18	13.48	18.20	
		Cladocera	0.09	0.12	31.04	
		Rotifera	13.99	16.12	14.16	
		Total abundance	31.95	31.82	0.42	
	MF3-7	Calanoida	2.84	2.89	1.88	0.08
		Cyclopoida	17.22	15.18	12.58	
		Cladocera	0.19	0.14	34.33	
		Rotifera	32.72	27.40	17.70	
		Total abundance	52.97	45.61	14.94	

Table B-1 **Results for Field QC (Duplicate) Zooplankton Abundance Samples Collected from Lac de Gras and Lac du Sauvage, 2020 (continued)**

Area	Station	Major Taxonomic Group	Total Abundance (Ind/L)		RPD (%)	Bray Curtis Dissimilarity Index
			Original Sample	Duplicate Sample		
FF1/FFD	FF1-2	Calanoida	1.71	0.99	**53.52**	0.04
		Cyclopoida	16.61	17.66	6.12	
		Cladocera	0.12	0.16	26.17	
		Rotifera	17.55	15.74	10.88	
		Total abundance	36.00	34.55	4.11	
	FFD-1	Calanoida	3.43	1.63	**71.23**	0.19
		Cyclopoida	13.86	14.35	3.48	
		Cladocera	0.13	0.20	40.60	
		Rotifera	20.84	10.19	**68.61**	
		Total abundance	38.26	26.37	36.80	

Note: **Bolded** values indicate RPD values greater than 50%.

QC = quality control; Ind/L = individuals per litre; RPD = relative percent difference; NF = near-field; MF = mid-field; FF = far-field.

Table B-2 Results for Field QC (Duplicate) Zooplankton Biomass Samples Collected from Lac de Gras and Lac du Sauvage, 2020

Area	Station	Major Taxonomic Group	Total Biomass (mg/m^3)		RPD (%)	Bray Curtis Dissimilarity Index
			Original Sample	Duplicate Sample		
NF	NF1	Calanoida	324.95	292.05	10.66	0.06
		Cyclopoida	121.64	139.24	13.49	
		Cladocera	45.74	24.97	**58.75**	
		Rotifera	7.39	9.54	25.45	
		Total biomass	499.72	465.80	7.03	
	NF2	Calanoida	204.85	236.37	14.28	0.05
		Cyclopoida	104.66	85.32	20.36	
		Cladocera	23.11	11.85	**64.44**	
		Rotifera	8.59	7.20	17.65	
		Total biomass	341.21	340.73	0.14	
	NF3	Calanoida	377.72	214.86	**54.97**	0.24
		Cyclopoida	178.62	129.68	31.75	
		Cladocera	9.34	4.39	**72.13**	
		Rotifera	13.66	7.30	**60.71**	
		Total biomass	579.34	356.22	47.70	
	NF4	Calanoida	492.36	330.73	39.27	0.17
		Cyclopoida	120.56	124.06	2.86	
		Cladocera	102.01	52.68	**63.77**	
		Rotifera	6.57	13.28	**67.59**	
		Total biomass	721.50	520.75	32.32	
	NF5	Calanoida	412.22	307.71	29.03	0.16
		Cyclopoida	107.31	58.11	**59.49**	
		Cladocera	16.03	35.29	**75.06**	
		Rotifers	9.76	8.15	17.91	
		Total biomass	545.31	409.26	28.51	
MF1	MF1-1	Calanoida	520.11	560.20	7.42	0.10
		Cyclopoida	114.85	211.91	**59.40**	
		Cladocera	30.23	38.47	23.98	
		Rotifera	9.28	11.10	17.80	
		Total biomass	674.48	821.68	19.68	
	MF1-3	Calanoida	501.61	395.85	23.57	0.09
		Cyclopoida	156.13	158.51	1.51	
		Cladocera	9.59	3.76	**87.36**	
		Rotifers	18.37	13.69	29.18	
		Total biomass	685.71	571.81	18.11	
	MF1-5	Calanoida	250.68	191.60	26.72	0.19
		Cyclopoida	300.29	209.50	35.62	
		Cladocera	42.67	7.48	**140.36**	
		Rotifera	4.79	2.90	49.26	
		Total biomass	598.43	411.47	37.03	
MF2	MF2-1	Calanoida	199.91	333.31	**50.04**	0.29
		Cyclopoida	67.04	118.35	**55.35**	
		Cladocera	29.92	79.40	**90.53**	
		Rotifera	4.67	12.14	**88.92**	
		Total biomass	301.53	543.19	**57.22**	
	MF2-3	Calanoida	216.58	473.77	**74.51**	0.29
		Cyclopoida	139.37	147.81	5.88	
		Cladocera	38.25	100.65	**89.85**	
		Rotifera	12.98	14.47	10.89	
		Total biomass	407.17	736.71	**57.62**	
	FF2-2	Calanoida	269.83	412.52	41.83	0.13
		Cyclopoida	93.11	110.72	17.29	
		Cladocera	188.20	184.22	2.14	
		Rotifera	11.63	5.93	**64.93**	
		Total biomass	562.76	713.39	23.61	
	FF2-5	Calanoida	242.40	388.34	46.27	0.22
		Cyclopoida	52.81	96.47	**58.48**	
		Cladocera	44.06	46.35	5.06	
		Rotifera	3.97	6.70	**51.01**	
		Total biomass	343.25	537.85	44.17	
MF3	MF3-1	Calanoida	123.58	136.48	9.92	0.05
		Cyclopoida	140.72	152.71	8.17	
		Cladocera	34.21	27.91	20.28	
		Rotifera	3.68	10.34	**94.94**	
		Total biomass	302.19	327.45	8.02	
	MF3-2	Calanoida	146.75	127.71	13.87	0.32
		Cyclopoida	269.27	82.35	**106.32**	
		Cladocera	20.15	13.59	38.87	
		Rotifera	3.71	2.17	**52.58**	
		Total biomass	439.89	225.83	**64.31**	
	MF3-3	Calanoida	229.82	139.32	49.04	0.32
		Cyclopoida	331.67	130.39	**87.12**	
		Cladocera	25.81	53.27	**69.45**	
		Rotifera	4.24	3.75	12.29	
		Total biomass	591.55	326.73	**57.68**	
	MF3-4	Calanoida	186.08	289.16	43.38	0.22
		Cyclopoida	168.12	237.36	34.15	
		Cladocera	40.28	85.42	**71.82**	
		Rotifera	4.67	5.53	16.72	
		Total biomass	399.16	617.47	42.95	
	MF3-5	Calanoida	149.33	141.12	5.65	0.05
		Cyclopoida	122.03	153.64	22.94	
		Cladocera	39.87	24.58	47.46	
		Rotifera	7.25	8.59	16.95	
		Total biomass	318.48	327.94	2.92	
	MF3-6	Calanoida	115.50	100.46	13.93	0.05
		Cyclopoida	126.51	152.85	18.86	
		Cladocera	59.27	41.94	34.25	
		Rotifera	3.23	3.65	12.28	
		Total biomass	304.50	298.90	1.86	
	MF3-7	Calanoida	172.11	191.60	10.72	0.10
		Cyclopoida	217.92	149.15	37.47	
		Cladocera	97.39	78.34	21.68	
		Rotifera	10.12	7.01	36.31	
		Total biomass	497.54	426.11	15.47	

Table B-2 Results for Field QC (Duplicate) Zooplankton Biomass Samples Collected from Lac de Gras and Lac du Sauvage, 2020 (continued)

Area	Station	Major Taxonomic Group	Total Biomass (mg/m^3)		RPD (%)	Bray Curtis Dissimilarity Index
			Original Sample	Duplicate Sample		
FF1/FFD	FF1-2	Calanoida	112.13	79.77	33.73	0.19
		Cyclopoida	145.30	125.54	14.59	
		Cladocera	110.57	45.35	**83.66**	
		Rotifera	7.34	5.35	31.37	
		Total biomass	375.34	256.01	37.80	
	FFD-1	Calanoida	136.46	83.72	47.90	0.19
		Cyclopoida	167.89	174.94	4.11	
		Cladocera	80.00	237.57	**99.23**	
		Rotifera	6.34	2.40	**90.18**	
		Total biomass	390.70	498.63	24.27	

Note: **Bolded** values are RPD values greater than 50%.

QC = quality control; mg/m^3 = milligrams per cubic metre; RPD = relative percent difference; NF = near-field; MF = mid-field; FF = far-field.

Split Samples

The laboratory QC program consisted of three phytoplankton and four zooplankton split samples in 2020.

The phytoplankton laboratory QC data indicated that the occurrence of dominant groups was consistent between the split samples (Table B-3 and Table B-4). The phytoplankton split sample results did not exceed an RPD of 50% for total abundance or biomass. However, an RPD of 50% was exceeded for diatom abundance and biomass in the FFD-1 and NF3 samples, dinoflagellate abundance and biomass in the NF3 and MF2-1 samples, cyanobacteria biomass in the MF2-1 sample, and microflagellate biomass in the FFD-1 sample. Despite these exceedances, the overall sample dissimilarity did not exceed the acceptance criterion (i.e., none of the samples had Bray-Curtis dissimilarity values greater than 0.5). Therefore, based on the split phytoplankton abundance and biomass results, samples were deemed acceptable for the purposes of this study.

The zooplankton laboratory QC data indicated that the occurrence of dominant groups was generally consistent between the split samples (Table B-5 and Table B-6). Although the zooplankton split sample results did not exceed an RPD of 50% for total abundance in 2020, an RPD of 50% was exceeded for cladoceran abundance in the NF3 sample. Total biomass, calanoid and cyclopoid copepod biomass, and rotifer biomass exceeded an RPD of 50% in the MF3-3 sample. Despite these exceedances, the overall sample dissimilarity did not exceed the acceptance criterion (i.e., none of the samples had Bray-Curtis dissimilarity values greater than 0.5). Therefore, based on the split zooplankton abundance and biomass results, the samples were deemed acceptable for the purposes of this study.

Table B-3 Results for Laboratory QC (Split) Phytoplankton Abundance Samples Collected from Lac de Gras and Lac du Sauvage, 2020

Area	Station	Major Taxonomic Group	Total Abundance (cells/L)		RPD (%)	Bray Curtis Dissimilarity Index
			Original Sample	Duplicate Sample		
NF	NF3	Microflagellates	541,695	429,861	23	0.17
		Diatoms	124,998	157,746	23	
		Chlorophytes	580,458	622,235	7	
		Cyanobacteria	2,912,117	1,830,345	46	
		Dinoflagellates	6,990	17,634	**86**	
		Total abundance	4,166,257	3,057,821	31	
MF2	MF2-1	Microflagellates	327,476	300,683	9	0.09
		Diatoms	50,890	78,400	43	
		Chlorophytes	464,581	750,618	47	
		Cyanobacteria	1,971,740	2,239,077	13	
		Dinoflagellates	26,953	8,971	**100**	
		Total abundance	2,841,640	3,377,748	17	
FFD	FFD-1	Microflagellates	439,973	549,427	22	0.05
		Diatoms	107,374	59,786	**57**	
		Chlorophytes	208,350	228,425	9	
		Cyanobacteria	624,289	616,250	1	
		Dinoflagellates	8,438	5,519	42	
		Total abundance	1,388,424	1,459,407	5	

Note: **Bolded** values indicate RPD values greater than 50%.

QC = quality control; cells/L = cells per litre; RPD = relative percent difference; NF = near-field; MF = mid-field; FF = far-field.

Table B-4 Results for Laboratory QC (Split) Phytoplankton Biomass Samples Collected from Lac de Gras and Lac du Sauvage, 2020

Area	**Station**	**Major Taxonomic Group**	**Total Biomass (mg/m^3)**		**RPD (%)**	**Bray Curtis Dissimilarity Index**
			Original Sample	**Duplicate Sample**		
NF	NF3	Microflagellates	354.3	219.6	47	0.23
		Diatoms	66.3	124.5	**61**	
		Chlorophytes	63.1	43.2	37	
		Cyanobacteria	4.9	3.4	38	
		Dinoflagellates	75.2	9.4	**156**	
		Total biomass	563.8	400.1	34	
MF2	MF2-1	Microflagellates	253.4	198.8	24	0.10
		Diatoms	47.9	55.5	15	
		Chlorophytes	25.1	39.3	44	
		Cyanobacteria	4.0	14.6	**114**	
		Dinoflagellates	11.8	3.5	**108**	
		Total biomass	342.2	311.7	9	
FFD	FFD-1	Microflagellates	82.0	164.4	**67**	0.23
		Diatoms	113.9	21.6	**136**	
		Chlorophytes	10.7	14.5	30	
		Cyanobacteria	0.8	0.8	3	
		Dinoflagellates	8.5	5.3	47	
		Total biomass	215.9	206.5	4	

Note: **Bolded** values indicate RPD values greater than 50%.

QC = quality control; mg/m^3 = milligrams per cubic metre; RPD = relative percent difference; NF = near-field; MF = mid-field; FF = far-field.

Table B-5 Results for Laboratory QC (Split) Zooplankton Abundance Samples Collected from Lac de Gras and Lac du Sauvage, 2020

Area	Station	Major Taxonomic Group	Total Abundance (Ind/L)		RPD (%)	Bray Curtis Dissimilarity Index
			Original Sample	Split Sample		
NF	NF3	Calanoida	5.35	4.21	23.92	0.07
		Cyclopoida	11.58	11.46	1.02	
		Cladocera	0.13	0.02	**155.09**	
		Rotifera	39.00	33.34	15.65	
		Total abundance	56.06	49.02	13.40	
MF3	MF3-3	Calanoida	3.00	2.12	34.19	0.09
		Cyclopoida	15.99	10.90	37.84	
		Cladocera	0.03	0.04	42.58	
		Rotifera	16.52	21.18	24.73	
		Total abundance	35.54	34.25	3.69	
MF2	FF2-5	Calanoida	4.13	3.30	22.27	0.03
		Cyclopoida	5.98	5.74	4.07	
		Cladocera	0.04	0.04	18.36	
		Rotifera	10.61	12.04	12.63	
		Total abundance	20.76	21.13	1.77	
FFD	FFD-1	Calanoida	1.63	1.74	6.33	0.10
		Cyclopoida	14.35	17.93	22.18	
		Cladocera	0.20	0.31	44.66	
		Rotifera	10.19	12.46	20.00	
		Total abundance	26.37	32.43	20.63	

Note: **Bolded** values are RPD values greater than 50%.

QC = quality control; Ind/L = Individuals per litre; RPD = relative percent difference; NF = near-field; MF = mid-field; FF = far-field.

Table B-6 Results for Laboratory QC (Split) Zooplankton Biomass Samples Collected from Lac de Gras and Lac du Sauvage, 2020

Area	Station	Major Taxonomic Group	Total Biomass (mg/m^3)		RPD (%)	Bray Curtis Dissimilarity Index
			Original Sample	Split Sample		
NF	NF3	Calanoida	377.72	273.20	32.12	0.15
		Cyclopoida	178.62	139.48	24.61	
		Cladocera	9.34	5.77	47.31	
		Rotifera	13.66	8.63	45.17	
		Total biomass	579.34	427.08	30.26	
MF3	MF3-3	Calanoida	229.82	132.20	**53.93**	0.27
		Cyclopoida	331.67	175.15	**61.76**	
		Cladocera	25.81	29.38	12.91	
		Rotifera	4.24	7.19	**51.62**	
		Total biomass	591.55	343.92	**52.94**	
MF2	FF2-5	Calanoida	242.40	197.25	20.54	0.09
		Cyclopoida	52.81	60.29	13.22	
		Cladocera	44.06	29.44	39.79	
		Rotifera	3.97	5.11	24.97	
		Total biomass	343.25	292.09	16.11	
FFD	FFD-1	Calanoida	83.72	83.39	0.40	0.03
		Cyclopoida	174.94	180.22	2.97	
		Cladocera	237.57	213.84	10.51	
		Rotifera	2.40	3.56	38.87	
		Total biomass	498.63	481.00	3.60	

Note: **Bolded** values are RPD values greater than 50%.

QC = quality control; mg/m3 = milligrams per cubic metre; RPD = relative percent difference; MF = mid-field; FF = far-field.

Summary

Data screening of 2020 phytoplankton and zooplankton community datasets did not identify anomalous values. The duplicate zooplankton samples were within the expected range of natural variability, and the split phytoplankton and zooplankton samples did not exceed the acceptance criteria. Therefore, the phytoplankton and zooplankton community datasets were deemed acceptable and used to complete the plankton community analysis in 2020.

References

Golder (Golder Associates Ltd.). 2017. Diavik Diamond Mine – Aquatic Effects Monitoring Program – Quality Assurance Project Plan (QAPP). Version 3.1. Prepared for Diavik Diamond Mines (2012) Inc. Yellowknife, NT, Canada. June 2017.

ATTACHMENT C

2020 PHYTOPLANKTON COMMUNITY DATA

These data are provided electronically in an Excel file.

ATTACHMENT D

2020 ZOOPLANKTON COMMUNITY DATA

These data are provided electronically in an Excel file.

APPENDIX XII

SPECIAL EFFECTS STUDY

No information was available for this appendix in 2020 as no Special Effects Studies were completed.

APPENDIX XIII

EUTROPHICATION INDICATORS REPORT

EUTROPHICATION INDICATORS REPORT IN SUPPORT OF THE 2020 AEMP ANNUAL REPORT FOR THE DIAVIK DIAMOND MINE, NORTHWEST TERRITORIES

Submitted to:

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1 Copy – Diavik Diamond Mines (2012) Inc., Yellowknife, NT
1 Copy – Golder Associates Ltd., Calgary, AB
1 Copy – Wek'èezhìı Land and Water Board

March 2021
20136424/10000

Doc No. RPT-2042 Ver. 0
PO No. 3104360642

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Executive Summary

In 2020, Diavik Diamond Mines (2012) Inc. (DDMI) completed the field component of the Aquatic Effects Monitoring Program (AEMP) for the Diavik Diamond Mine (Mine) in Lac de Gras, Northwest Territories, as required by Water Licence W2015L2-0001 (WLWB 2015), according to the *AEMP Design Plan Version 4.1* (Golder 2017a), as approved by the Wek'èezhìı Land and Water Board (WLWB). This report presents the assessment of eutrophication indicators data collected during the 2020 AEMP. The objective of this component of the AEMP was to evaluate whether Mine-related activities are having an effect on concentrations of nutrients, chlorophyll *a*, and phytoplankton and zooplankton biomass in Lac de Gras. In 2020, Mine-related inputs that had the potential to affect Lac de Gras included effluent discharge and dust deposition. No dyke construction or dewatering activities occurred in 2020.

To evaluate whether effluent from the Mine is causing nutrient enrichment in Lac de Gras, indicators of eutrophication were measured in the near-field (NF) and mid-field (MF) areas of the lake, and at two stations (FF1-2 and FFD-1) that have recently been added to the annual monitoring program. Eutrophication indicators evaluated by the AEMP were total and dissolved phosphorus (TP and TDP), soluble reactive phosphorus (SRP), total and dissolved nitrogen (TN and TDN), total ammonia, nitrate, nitrite, nitrate + nitrite, total and dissolved Kjeldahl nitrogen (TKN and DKN), soluble reactive silica (SRSi), chlorophyll *a*, phytoplankton biomass as biovolume, and zooplankton biomass as ash-free dry mass (AFDM). Secchi depth was also included in the analysis as supporting information for the interpretation of the results for phytoplankton biomass and chlorophyll *a*. The analysis of potential effects focused on spatial trends in Lac de Gras using a gradient approach.

The assessment of the 2020 eutrophication indicators dataset concluded that the Mine is having a nutrient enrichment effect in Lac de Gras. The annual load of phosphorus to Lac de Gras in 2020 was similar to the 2019 annual load. Phosphorus concentrations in lake water were within or below the normal range at most stations, with no apparent spatial trends. Therefore, the extent of effect on TP was estimated as 0% of Lac de Gras. The 2020 monthly loads of nitrogen parameters to Lac de Gras, and concentrations in AEMP sampling areas, were similar or greater in 2020 compared to 2019. Nitrogen concentrations were above the normal range in a large proportion of Lac de Gras, and concentrations decreased with distance from the diffuser. The extent of effect on TN was 40% of lake area during the open-water season and greater than or equal to 48% during the ice-cover season. Significant decreasing trends in SRSi concentration were observed with distance from the diffusers. There were no apparent seasonal differences in concentrations of TP, TN, and SRSi.

Chlorophyll *a* concentrations and zooplankton biomass were greater in the NF area compared to other parts of the lake, and decreased with distance from the diffuser. These variables were above the normal range in the NF area and at most stations in the MF areas. Total phytoplankton biomass also decreased with distance from the diffuser, but was generally within the normal range. The 2020 chlorophyll *a* results and zooplankton biomass displayed a response consistent with nutrient enrichment. The extent of effects on chlorophyll *a*, phytoplankton biomass, and zooplankton biomass were 22%, 2.8%, and 57% of Lac de Gras, respectively.

The concentration of chlorophyll *a* in the NF and MF areas was above the normal range in an area representing more than 20% of the lake. Based on these results, Action Level 2 was triggered for nutrient enrichment. According to the Response Framework, exceedance of Action Level 2 requires an action to

establish an Effects Benchmark; however, as previous AEMP reports have triggered Action Level 2, the Effects Benchmark has been previously established. Therefore, no further action is required.

The 2020 results are consistent with the Environmental Assessment prediction of elevated concentrations of nutrients in lake water, particularly phosphorus, resulting from the minewater discharge, and an associated increase in primary productivity. Although a clear effect on phosphorus concentrations in lake water was not detected, likely due to rapid utilization of this nutrient, Mine-related phosphorus loading is the most likely factor accounting for the observed biological effects. The combined results of nutrient–productivity indicator relationships, year-to-year variation in affected areas for nutrients and productivity indicators, and nutrient ratios calculated previously suggest at most a limited influence of nitrogen loading from the Mine effluent on primary producers in Lac de Gras.

The 2020 AEMP provided no evidence that dust deposition had an additional measurable effect on concentrations of TP or chlorophyll *a* in Lac de Gras, beyond the effect apparent from the Mine effluent discharge.

Overall, the results of the 2020 AEMP are consistent with those reported in previous AEMP years as summarized in the *2017 to 2019 Aquatic Effects Re-evaluation Report* (Golder 2020b) and subsequent AEMP annual reports (i.e., 2017, 2018, 2019).

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Acronyms and Abbreviations

AEMP	Aquatic Effects Monitoring Program
AFDM	ash-free dry mass
AIC	Akaike’s information criterion
AICc	Akaike’s information criterion corrected for small sample size
ALS	ALS Laboratories
Biologica	Biologica Environmental Services, Ltd.
BV Labs	Bureau Veritas Laboratories (BV Labs; formerly Maxxam Analytics)
CALA	Canadian Association of Laboratory Accreditation
DDMI	Diavik Diamond Mines (2012) Inc.
DKN	dissolved Kjeldahl nitrogen
DL	detection limit
DQO	data quality objectives
EA	environmental assessment
e.g.	for example
et al.	and more than one additional author
EQC	effluent quality criteria
FF	far-field
Golder	Golder Associates Ltd.
i.e.	that is
LDG	Lac de Gras
LDS	Lac du Sauvage
MF	mid-field
Mine	Diavik Diamond Mine
Mine centroid	geographic centre of the Mine
n	sample size/count
NIWTP	North Inlet Water Treatment Plant
NF	near-field
QA/QC	quality assurance/quality control
QA	quality assurance
QAPP	Quality Assurance Project Plan
QC	quality control
r	Pearson correlation coefficient
r^2 or R^2	coefficient of determination
RPD	relative percent difference
SES	special effects study
SNP	surveillance network program
SOP	standard operating procedure
SRSi	soluble reactive silica
SRP	soluble reactive phosphorus

TKN	total Kjeldahl nitrogen
TN	total nitrogen
TP	total phosphorus
TDN	total dissolved nitrogen
TDP	total dissolved phosphorus
WLWB	Wek'èezhìı Land and Water Board
ZOI	zone of influence

Symbols and Units of Measure

%	percent
<	less than
>	greater than
≥	greater than or equal to
×	times
µm	micrometre
cm	centimetre
dm^2	square decimetre
kg	kilogram
kg/mo	kilograms per month
kg/yr	kilograms per year
km	kilometre
km^2	square kilometre
L	litre
m	metre
$mg/dm^2/yr$	milligrams per square decimetre per year
mg/L	milligrams per litre
mg/m^3	milligrams per cubic metre
mL	millilitre
mo	month
P	probability
t	tonne
t/yr	tonnes per year
yr	year
µg/L	micrograms per litre
µg-N/L	micrograms nitrogen per litre
µg-P/L	micrograms phosphorus per litre

1 INTRODUCTION

1.1 Background

As required by Water Licence W2015L2-0001 (WLWB 2015) issued by the Wek'èezhìı Land and Water Board (WLWB), Diavik Diamond Mines (2012) Inc. (DDMI) has been monitoring indicators of eutrophication in Lac de Gras (LDG) as a component of the Aquatic Effects Monitoring Program (AEMP) since 2007. Eutrophication indicators are a key component of the AEMP, because the Environmental Assessment (EA) predicted that the discharge of effluent from the Diavik Diamond Mine (Mine) would cause a change in trophic status (which is a classification of primary productivity) in up to 20% of Lac de Gras as a result of nutrient enrichment (Government of Canada 1999).

Although *AEMP Design Plan Version 4.1* (Golder 2017a) is the approved version of the AEMP design at the time this report was written, a number of updates outlined in the proposed *AEMP Design Plan Version 5.2* (Golder 2020a) and approved through the Wek'èezhìı Land and Water Board directives (25 March 2019, 21 October 2019, and 4 June 2020 Decision Packages related to the *2014 to 2016 Aquatic Effects Re-evaluation Report*, *AEMP Design Plan Version 5.0*, *2017 AEMP Annual Report*, *2018 AEMP Annual Report,* and *AEMP Design Plan Version 5.1*) have been incorporated into the 2020 Eutrophication Report. These updates include revisions to the sampling stations for the 2020 field program, and additional data analysis, including the presentation of spatial extent of effects in interim monitoring years.

This report presents the assessment of eutrophication indicators data collected during the 2020 AEMP field program. The potential influence of other Mine-related sources on lake productivity, such as dust deposition, are also considered herein.

1.2 Objectives

The primary objective of the eutrophication indicators assessment is to determine if effluent discharged from the Mine is having an effect on concentrations of nutrients, chlorophyll *a*, and phytoplankton and zooplankton biomass in Lac de Gras.

1.3 Scope and Approach

The Eutrophication Indicators component is designed to monitor both spatial and temporal changes in nutrients, chlorophyll *a*, and phytoplankton and zooplankton biomass. Eutrophication indicators selected for this AEMP component are total and dissolved phosphorus (TP and TDP), soluble reactive phosphorus (SRP), total and dissolved nitrogen (TN and TDN[1]), total ammonia, nitrate, nitrite, nitrate + nitrite, total and dissolved Kjeldahl nitrogen (TKN and DKN), soluble reactive silica (SRSi), chlorophyll *a*, phytoplankton biomass as biovolume, and zooplankton biomass as ash-free dry mass (AFDM). Secchi depth is also included in the analysis and used, as appropriate, in the interpretation of results for phytoplankton biomass and chlorophyll *a*. The spatial extent of effects is established by estimating the surface area of the lake that demonstrates concentrations or biomass greater than background values. Background values for Lac de Gras are those that fall within the range of natural variability, referred to as the normal range, as described

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[1] TN and TDN are calculated based on measured variables according to the following equations: TN = TKN + (nitrate + nitrite) and TDN = DKN + (nitrate + nitrite).

in Section 1.2 of the *AEMP Reference Conditions Report Version 1.4* (Golder 2019a). The magnitude of effects is assessed by comparing eutrophication indicator endpoints in the near-field (NF), mid-field (MF), and far-field (FF) areas to background values. Values above the normal range exceed what would be considered natural levels for Lac de Gras. The importance of effects observed on eutrophication endpoints is assessed according to the Action Level classification defined by Golder (2017a).

The AEMP measures and evaluates the effects of Mine-related activities on the aquatic environment of Lac de Gras. Mine-related activities in 2020 that had the potential to affect Lac de Gras include effluent discharge and dust deposition from vehicular and heavy equipment operations within the Mine footprint. No dyke construction or dewatering activities occurred in 2020.

2 METHODS

2.1 Field Sampling

2.1.1 Effluent and Mixing Zone

Treated effluent was sampled from the two diffusers that discharge water from the North Inlet Water Treatment Plant (NIWTP) to Lac de Gras, as part of the Mine's Surveillance Network Program (SNP). Station SNP 1645-18 is located at the original diffuser, which has discharged continuously to Lac de Gras since 2002, and Station SNP 1645-18B is located at the second diffuser, which became operational on 13 September 2009. In addition, water quality samples were collected at the mixing zone boundary in Lac de Gras at three stations (i.e., SNP 1645-19A, SNP 1645-19B2, and SNP 1645-19C), which are located along a semicircle, at 60 m from the effluent diffusers. These stations represent the edge of the mixing zone, which covers an area of approximately 0.01 km^2. Station SNP 1645-19B2 was established in 2009 to replace Station SNP 1645-19B, after the second diffuser became active in Lac de Gras.

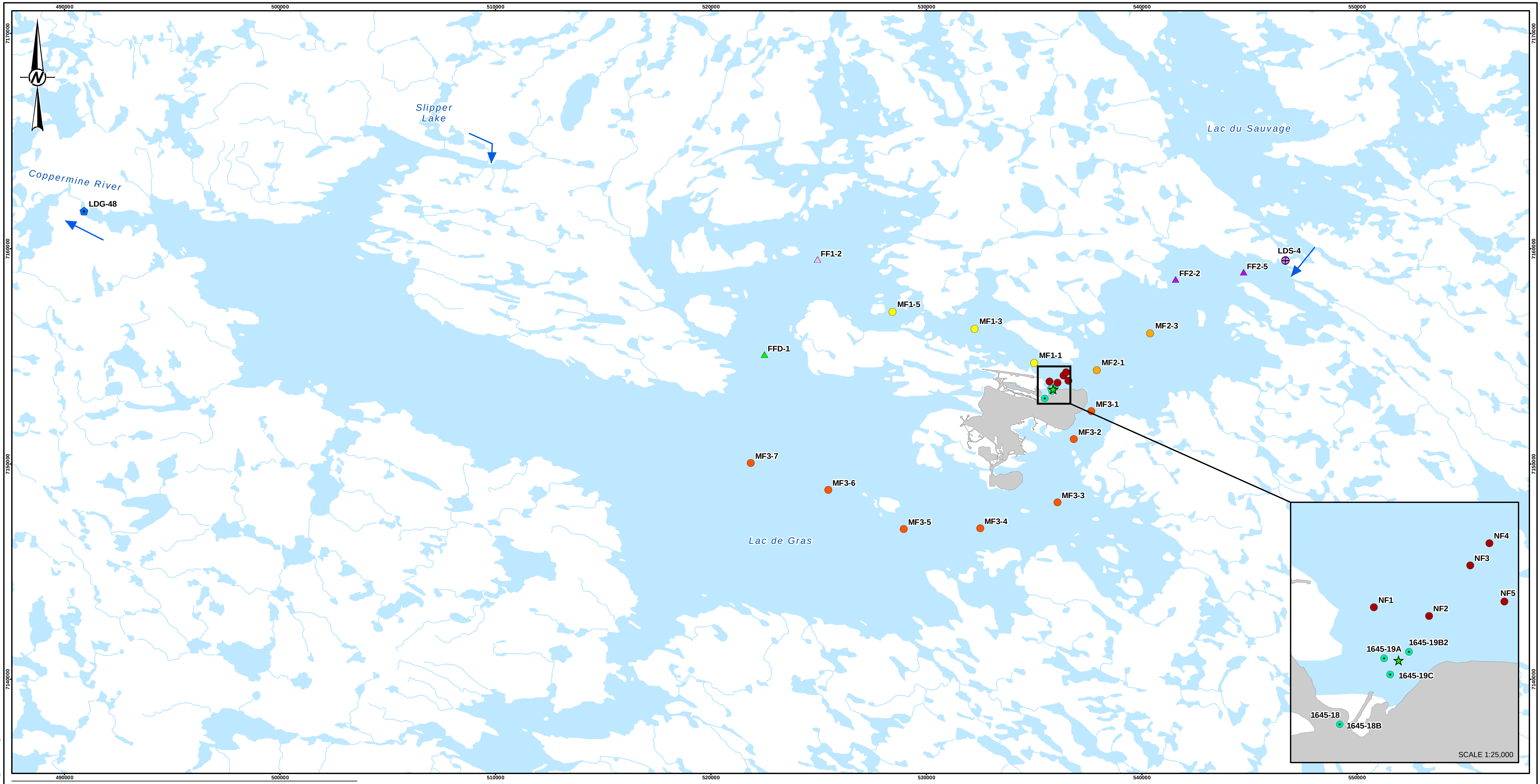
Effluent samples were collected approximately every six days. At the mixing zone boundary, samples were collected monthly at each station at the lake water surface and at 5 m depth intervals. Samples were not collected during ice-off (June) at the mixing zone stations due to unsafe ice conditions that prevented access.

2.1.2 Lac de Gras

Twenty-one stations located in six general areas of Lac de Gras were sampled by DDMI during the 2020 AEMP (Figure 2-1, Table 2-1). Sampling areas were selected based on exposure to the Mine effluent (Golder 2017a), and consisted of the NF area, three MF areas, and two FF areas. Per the WLWB directives approving a number of updates outlined in the proposed *AEMP Design Plan Version 5.2* (Golder 2020a), FF1-2 will be sampled during interim monitoring years, instead of only being sampled in comprehensive years, and a new station, FFD-1, will also be sampled during interim monitoring years. These updates were included in the 2020 monitoring program.

Sampling stations in the MF areas follow transect lines that run from the NF area towards the FF areas (i.e., FF1, FFA, and FFB [although the latter two FF areas are not sampled in interim years and, therefore, are not shown on Figure 2-1]). The MF1 transect is located northwest of the NF area and runs towards the FF1 area. The MF2 transect is located to the northeast, and includes the FF2 stations near the Lac du Sauvage (LDS) inlet. The MF3 transect is located south of the NF area, and runs towards the FFB and FFA areas.

In addition to the 21 stations in Lac de Gras, stations located at the outlet of Lac de Gras to the Coppermine River (LDG-48) and at the narrows between Lac de Gras and Lac du Sauvage (LDS-4) were also sampled.



LEGEND

★	DIFFUSERS
⊙	SURVEILLANCE NETWORK PROGRAM

STATION LOCATIONS

△	FAR-FIELD 1
▲	FAR-FIELD 2
▲	FAR-FIELD D
⬟	LAC DE GRAS OUTLET
⊕	LAC DU SAUVAGE OUTLET
●	MID-FIELD 1
●	MID-FIELD 2
●	MID-FIELD 3
●	NEAR-FIELD

→	FLOW DIRECTION
—	WATERCOURSE
▨	DIAVIK FOOTPRINT
▨	WATERBODY

0 5 10

1:175,000 KILOMETRES

REFERENCE(S)
HYDROGRAPHY DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
PROJECTION: UTM ZONE 12 DATUM: NAD 83

CLIENT
RioTinto

PROJECT
DIAVIK DIAMOND MINES (2012) INC.

CONSULTANT
GOLDER

YYYY-MM-DD	2021-03-22
DESIGNED	MC
PREPARED	LMS
REVIEWED	MC
APPROVED	RLS

TITLE
LOCATIONS OF AEMP EUTROPHICATION INDICATORS SAMPLING STATIONS, 2020

PROJECT NO.	PHASE	REV.	FIGURE
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Table 2-1 Eutrophication Indicators Sampling Station Locations, 2020

Area	Station	UTM Coordinates[a] Easting (m)	UTM Coordinates[a] Northing (m)	Distance from Diffuser[b] (m)	Water Depth (m)
NF	NF1	535740	7153854	394	22.3
	NF2	536095	7153784	501	20.6
	NF3	536369	7154092	936	18.6
	NF4	536512	7154240	1,131	21.1
	NF5	536600	7153864	968	20.6
MF1	MF1-1	535008	7154699	1,452	19.5
	MF1-3	532236	7156276	4,650	18.9
	MF1-5	528432	7157066	8,535	18.0
MF2	MF2-1	538033	7154371	2,363	18.0
	MF2-3	540365	7156045	5,386	20.3
	FF2-2	541588	7158561	8,276	19.1
	FF2-5	544724	7158879	11,444	20.0
MF3	MF3-1	537645	7152432	2,730	19.7
	MF3-2	536816	7151126	4,215	22.6
	MF3-3	536094	7148215	7,245	20.6
	MF3-4	532545	7147011	11,023	20
	MF3-5	528956	7146972	14,578	18.6
	MF3-6	525427	7148765	18,532	18.0
	MF3-7	521859	7150039	22,330	21.5
FF1	FF1-2	524932	7159476	12,915	19.0
FFD	FFD-1	522495	7155084	17,315	19.5
Outlet of Lac de Gras	LDG-48	490900	7161750	55,556	2.2
Outlet of Lac du Sauvage	LSD-4	546797	7159595	-	0.4

a) UTM coordinates are reported as Zone 12, North American Datum (NAD) 83.

b) Approximate distance from the Mine effluent diffusers along the most direct path of effluent flow.

UTM = Universal Transverse Mercator coordinate system; - = not applicable; NF = near-field; MF = mid-field; FF = far-field; Lac du Sauvage.

The field sampling program included the collection of water samples for analysis of nutrients and chlorophyll *a*, phytoplankton and zooplankton samples for biomass analysis, and *in situ* water quality measurements. Sampling was conducted once during ice-cover season and once during the open-water season (Attachment A):

- ice-cover season sampling period: 20 April to 1 May 2020
- open-water season sampling period: 16 August to 7 September 2020

Nutrient samples were collected in both seasons, while chlorophyll *a*, phytoplankton, and zooplankton samples were collected during the open-water season only. The sampling protocol for nutrients differed between the ice-cover and open-water seasons, according to DDMI Standard Operating Procedure (SOP), ENVI-923-0119 AEMP "Combined Open-Water and Ice-Cover" and as described below. Water samples were handled according to DDMI SOPs, ENVI-902-0119 "Quality Assurance Quality Control" and ENVI-900-0119 "Chain of Custody".

Because the effluent may not be vertically mixed under ice-cover and water chemistry may differ among depths, samples were collected at three discrete depths during the ice-cover season. Duplicate samples were collected at the top, middle, and bottom depths at each NF, MF, and FF2 station, and at a single depth (i.e., middle) at the FF1-2, FFD-1, and LDG-48 stations. Surface samples were collected at a depth of 2 m from ice surface, and bottom samples were collected 2 m from the lake bottom. Mid-depth samples were collected at the middle of the total water column depth. No sample was collected at LDS-4 during the ice-cover season.

During the open-water season, duplicate depth-integrated water samples were collected at each station for the analysis of nutrients and chlorophyll *a*. Per Section 3.4.2 of the *AEMP Design Plan Version 4.1* (Golder 2017a), only water quality, nutrients, and chlorophyll *a* were sampled at LDG-48 and LDS-4. These stations are shallow, which does not allow quantitative plankton sampling using a plankton net.

Depth-integrated water samples were collected at deep stations for nutrient analysis to provide an estimate of the concentrations of nutrients to which phytoplankton are exposed. These samples were collected from the top 10 m of the water column using a depth-integrated sampler. A second depth-integrated sample was collected to produce duplicate samples for nutrients and chlorophyll *a* at each station. The phytoplankton biomass (as biovolume) data presented herein were taken from the *Plankton Report* (Appendix XI); however, samples were collected in the same manner as for nutrients and chlorophyll *a*, with the exception that twelve depth-integrated samples at a station were combined, and the resulting composite sample was used to fill a sample bottle for phytoplankton taxonomy.

Duplicate zooplankton samples were collected using a plankton net (30 cm mouth diameter, 75 µm mesh) for the determination of zooplankton biomass as AFDM. Each sample consisted of a composite of three vertical hauls through the entire water column.

2.2 Laboratory Analysis

Nutrient samples, excluding SRSi, were sent for analysis to Bureau Veritas Laboratories (BV Labs; formerly Maxxam Analytics), Edmonton or Calgary, Alberta. All open-water samples were analyzed by BV Labs in Edmonton; the ice-cover samples were divided between Edmonton and Calgary. The SRSi samples were sent to ALS Laboratories (ALS) in Vancouver. As in recent years, filtering of the dissolved nutrients samples in 2020 was performed at BV Labs. Duplicate samples for total ammonia analysis were also sent to ALS in Vancouver. To be consistent with the dataset used in the *Effluent and Water Chemistry Report* (Appendix II), total ammonia data from ALS were used in the data analysis (see Section 2.3.1 in the *Effluent and Water Chemistry Report* [Appendix II]).

A list of the nutrients analyzed and the analyte-specific detection limits (DLs) reported in 2020 are provided in Table 2-2. The target DL as stated in the design plan was not achieved for some samples due to insufficient sample volume or other problems with the original sample (e.g., interference by other analytes). Deviations from the target DLs and a discussion of potential effects on data quality are discussed in Attachment C. Raw nutrient data are provided in Attachment G.

Table 2-2 Detection Limits for Nutrient Analysis, 2020

Variable	Unit	Detection Limit
Nutrients		
Total phosphorus	µg-P/L	2
Total dissolved phosphorus	µg-P/L	2
Soluble reactive phosphorus	µg-P/L	1
Total nitrogen	µg-N/L	20
Total dissolved nitrogen	µg-N/L	20
Total Kjeldahl nitrogen	µg-N/L	20
Dissolved Kjeldahl nitrogen	µg-N/L	20
Total ammonia	µg-N/L	5
Nitrate	µg-N/L	2
Nitrite	µg-N/L	1
Nitrate + nitrite	µg-N/L	2 or 2.2(a)
Soluble reactive silica	µg/L	10

a) All ice-cover samples met target DL of 2 µg/L; all open-water samples had DL of 2.2 µg/L

µg-P/L = micrograms phosphorus per litre; µg-N/L = micrograms nitrogen per litre; µg/L = micrograms per litre.

Depth-integrated chlorophyll *a* samples were sent to the Biogeochemical Analytical Service Laboratory at the University of Alberta, Edmonton, Alberta. Samples were analyzed for chlorophyll *a* at a DL of 0.04 µg/L. Composite phytoplankton samples were submitted to Biologica Environmental Services, Ltd. (Biologica), Victoria, British Columbia, for analysis of abundance and biomass. Analytical methods are presented in the *Plankton Report* (Appendix XI). Zooplankton biomass (as AFDM) was measured by BV Labs, Calgary, Alberta.

2.3 Quality Assurance/Quality Control

The *Quality Assurance Project Plan Version 3.1* (QAPP; Golder 2017b) outlines the quality assurance (QA) and quality control (QC) procedures employed to support the collection of scientifically defensible and relevant data required to meet the objectives of the *AEMP Design Plan Version 4.1* (Golder 2017a). The QAPP is designed so that field sampling, laboratory analysis, data entry, data analysis, and report preparation activities produce technically sound and scientifically defensible results. A description of the QA/QC practices applied to the eutrophication indicators component of the 2020 AEMP and an evaluation of the QC data are provided in Attachment C. Nutrient data collected during the 2020 AEMP were considered to be of acceptable quality, with the exception of total ammonia and five values that had multiple QC failures. Each data quality issue is discussed below.

Data quality issues with total ammonia continue to be a concern, with occasional detections in blank samples, and relatively high variability between duplicate samples. As discussed in the *Effluent and Water Chemistry Report* (Appendix II), some of these issues may be related to the low DL used for total ammonia (0.005 mg/L), which is at the absolute limit of instrument sensitivity. Therefore, concentrations measured close to the DL, which frequently occur in the eutrophication indicators dataset, are subject to large uncertainty.

As discussed in the *Effluent and Water Chemistry Report* (Appendix II), BV Labs identified a contamination issue for total ammonia in both the ice-cover and open-water datasets. An interlaboratory comparison study conducted by BV Labs suggested that the total ammonia data generated by ALS had fewer data quality issues and should, therefore, be used for the data analysis. This suggestion was accepted and the total ammonia data generated by ALS for both seasons were used in the 2020 AEMP data analysis.

Five values were removed from the dataset prior to anomalous value screening, generating plots, and statistical analysis because of multiple QC failures. These values and the rationales for their removal are provided below:

- The reported TN and TKN values for MF3-7T-5 collected during the ice-cover season were removed from the dataset. These values were non-detect (<20 µg-N/L) compared to their duplicates (170 µg-N/L) and failed the data quality objectives (DQOs) with relative percent differences (RPD) of 178%. They were also not consistent with those reported for the bottom and top depths. Sample MF3-7T-5 was re-analyzed for TN and TKN, but because the laboratory re-analyzed at a dilution, the results were variable and could not be reliably reported. Three lines of evidence suggest that this reported non-detect value is not representative of concentrations at this station: 1) there are measurable concentrations at other depths that are similar to each other; 2) there are measurable dissolved concentrations for this sample; and 2) concentrations at other depths are consistent with concentrations measured at nearby stations.
- The reported TDP value of 11.9 µg-P/L for MF3-5-5 collected during the open-water season was removed from the dataset. This value was higher than its duplicate (<2 µg-P/L) and failed the DQO with an RPD of 169%. The sample was not re-analyzed by the laboratory. This reported TDP value was not considered representative at this station because the corresponding TP value was much lower (non-detect at detection limit of 2 µg-P/L) and consistent with other TP concentrations at nearby stations.
- The reported TDN and DKN values for NF1-5 collected during the open-water season were removed from the dataset. These values were both 13,000 µg-N/L, which were two orders of magnitude higher than their duplicates (TDN = 220 µg-N/L, DKN = 160 µg-N/L) and the corresponding TN and TKN values (TN = 220 µg-N/L, TKN = 170 µg-N/L). The sample was not re-analyzed by the laboratory. The reported TDN and DKN values were not considered representative at this station because the concentrations were much higher in this sample relative to: those measured in the field duplicate, those of the total nitrogen fractions, and concentrations at nearby stations.

Four other values were considered notable but were retained in the dataset. These values and the rationale for their notability are provided below:

- The reported nitrate and nitrate + nitrite values of 51 µg-N/L for FFD-1M-5 were for a sample collected during the ice-cover season. The corresponding values for the duplicates were non-detect (i.e., <2 µg-N/L). This is the first year this station has been sampled and thus there are no historical data for comparison. Although the RPD is high (192%), these values were not identified as anomalous in the screening step (Attachment B), and the average concentrations for this station were reasonable given the concentrations at nearby stations (see Figures 3-24 and 3-25). Therefore, the results were retained in the dataset for generating plots and statistical analysis.
- The reported TDP values of 5.5 µg-P/L at NF2 bottom depth and 7.1 µg-P/L at NF2 mid depth during the ice-cover season are suspected to be biased high. These values were not considered a QC failure, given that they are still within 5 times the DL; however, both values were greater than the corresponding TP values, and presented with high RPDs (i.e., 89% and 67%, respectively). These values were not identified as anomalous and were retained within the dataset for generating plots and performing statistical analysis.
- The reported TN value of 475 µg-N/L for FFD-1 was measured during the open-water season. Nitrate + nitrite was not detected in this sample, and the corresponding values for the other nitrogen species (i.e., TDN, TKN, and DKN) were substantially lower and therefore, this value was considered likely to be inaccurate. This value was not identified as anomalous and was retained in the dataset for generating plots; however, for the extent of effects calculations (Section 2.4.4.3), the maximum values from the alternate nitrogen species (i.e., TDN, TKN, and DKN) were used instead of the reported TN value. This resulted in the value used in the extent of effects calculations being adjusted from 475 µg-N/L to 150 µg-N/L, which was the reported result for TKN at FFD-1 during the open-water season.

Zooplankton biomass as AFDM may be biased low due to an error by the analytical laboratory, which accidentally removed an aliquot of approximately 60 mL from all but four zooplankton bottles to use for a different analysis. The affected sample bottles were not shaken before the aliquot was taken. The removal of this aliquot had the potential to remove zooplankton from the original sample and thus could result in zooplankton biomass estimates that were biased low. However, because the bottles were not shaken before the aliquot was taken, the effects were expected to be minimal. To evaluate the influence of the aliquot removal on zooplankton biomass and confirm the expectations of minimal effects, the four unimpacted samples were treated the same way as the other impacted samples, with the exception that decanted aliquots of 60 mL were also analyzed for zooplankton biomass. The results suggest that very few zooplankton were present in the aliquots (i.e., <2% of the total zooplankton biomass; Attachment C, Table C-1). A 2% bias is unlikely to be distinguishable from other sources of variability (e.g., variability between field duplicates, or variability between years) and thus is not expected to affect the interpretation of results for this parameter. Therefore, the AFDM results were not corrected in any way as a result of this incident.

2.4 Data Analysis

2.4.1 Data Screening

Initial screening of the 2020 nutrient, chlorophyll *a*, and zooplankton biomass (as AFDM) datasets was completed before generating plots and statistical analyses to identify unusually large (or small) values and decide whether to retain or exclude anomalous data from further analysis. The anomalous data screening methods are described in the QAPP (Golder 2017b). This screening was done on the individual sample results (i.e., duplicate data were not averaged).

Data screening for anomalous values identified three anomalous values in the 2020 eutrophication indicators dataset, representing 0.1% of the dataset (Appendix B; Table B-1). In cases where unusual values were identified in the dataset, scatterplots were generated to allow a visual review of the data and provide transparency (Appendix B; Figures B-1 and B-2). This review indicated that the anomalous values identified by numerical screening were unusual in terms of the 2020 dataset. In addition, these values had QC issues related to high RPDs for duplicates (Attachment C). Therefore, the three anomalous values were excluded from further analysis.

2.4.2 Censored Data

For the purposes of the AEMP, censored data are concentrations reported below the analytical DL (<DL, referred to as non-detect values). Due to the location of Lac de Gras on the Canadian Shield, concentrations of many water quality variables are low and at or <DL. A frequently used, simple approach to deal with censored data is the substitution of a surrogate value (e.g., the DL or some fraction of the DL) for non-detect data, which is considered generally acceptable in cases when a relatively small proportion of the data (e.g., <15%) are <DL. Prior to data analyses, non-detect values were substituted with half the DL (i.e., 0.5 times the DL). This approach for handling censored data (US EPA 2000) is consistent with the approved methods applied in the calculation of the normal range in the *AEMP Reference Conditions Report Version 1.4* (Golder 2019a). Data measured at <DL are presented on plots at half the DL.

2.4.3 Effluent and Mixing Zone

The quantity of nutrients in effluent was evaluated graphically by plotting total monthly loads of nutrients. The daily load from each diffuser was calculated by multiplying the effluent discharge rate by the nutrient concentration at each effluent diffuser station (i.e., SNP 1645-18 and SNP 1645-18B). The total daily load was calculated as the sum of loads from the two diffusers. Total monthly loads represent the sum of the total daily loads for a given month. The period of effluent discharge summarized in this report (i.e., the reporting period) was from 1 November 2019 to 31 October 2020.

Time series plots showing the concentrations of nutrients in effluent were generated for the reporting period. Results for individual grab samples were plotted separately for each effluent diffuser station (i.e., SNP 1645-18 and SNP 1645-18B).

Water was sampled at the mixing zone boundary monthly[2], at five depths (i.e., 2, 5, 10, 15, and 20 m) at each of the three mixing zone stations (i.e., SNP 1645-19A, SNP 1645-19B, SNP 1645-19C). Hence, up to 15 samples were collected each month. Results were summarized as boxplots showing 10th, 25th, 50th (median), 75th, and 90th percentile concentrations, circles represent the 5th and 95th percentile concentrations.

The quality of the effluent was assessed in the *Effluent and Water Chemistry Report* (Appendix II) by comparing water chemistry results at stations SNP 1645-18 and SNP 1645-18B with the Effluent Quality Criteria (EQC) defined in the Water Licence (WLWB 2015). Results for key nutrient variables are presented herein, specifically TP, TDP, SRP, TN, total ammonia, nitrate, and nitrite. Total phosphorus has an EQC specified in terms of load, rather than concentration. The Water Licence specifies that the load of TP must not exceed a maximum of 300 kg/mo, an average annual load of 1,000 kg/yr during the life of the Mine, and a maximum load of 2,000 kg/yr in any year during the life of the Mine.

2.4.4 Lac de Gras

2.4.4.1 Gradient Analysis

The spatial gradients in water quality variables along the three MF transects were analyzed using linear regression, as described in the *AEMP Design Plan Version 4.1* (Golder 2017a). The NF area data were included in the linear regression for each of the three MF transects. Hereafter, the NF-MF1 transect is referred to as MF1, the NF-MF2-FF2 transect is referred to as MF2, and the NF-MF3 transect is referred to as MF3. The stations included in each of the MF transects are described in Section 2.1. A single maximum value of either top, middle or bottom depth samples for the three MF transects was used for each station in the regression analysis. Regression analyses were considered significant at $\alpha = 0.05$.

Due to the length of the MF3 transect, variables often had non-linear patterns with distance from the diffusers. Therefore, the analysis method allowed for piecewise regression (also referred to as segmented, or broken stick regression). Two approaches were used:

- Model 1: a linear multiplicative model, with main effects of distance from diffusers, gradient (MF1, MF2, and MF3 transects), and their interaction
- Piecewise modelling to account for changes in spatial gradients in MF3, where MF1 and MF2 were analyzed separately from MF3:
  - Model 2: a linear multiplicative model, with main effects of distance from diffusers, gradient (MF1 and MF2 transect only), and their interaction
  - Model 3: a linear piecewise (i.e., broken stick) model with distance (MF3 transect only)

For each variable in each season, Model 1 was used to test for presence of a significant ($P<0.05$) breakpoint using the Davies test (Davies 1987, 2002). If a significant breakpoint was identified, Models 2 and 3 were

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[2] Samples at the mixing zone boundary were not sampled in June 2020 due to unsafe ice conditions.

used for that variable in that season. If no significant breakpoint was identified, Model 1 was used for that variable in that season.

Following the initial fit of the model, the residuals (of either Model 1 or Model 2, as applicable) were used to examine whether data needed to be transformed to meet regression assumptions. Model 3 was not considered for transformations, since the addition of breakpoint was expected to resolve non-linear patterns. For each response variable in each season, the data underwent Box-Cox transformations (Box and Cox 1964). The Box-Cox transformations are a family of transformations that include the commonly used log and square root transformations. The Box-Cox transformation process tests a series of power values, usually between -2 and +2, and records the log-likelihood of the relationship between the response and the predictor variables under each transformation. The transformation that maximizes the log-likelihood is the one that will best normalize the data. Therefore, the data are transformed using a power value identified by the transformation process. For a power value (λ) of zero, the data are natural log transformed. The transformation rules can be described using the following definitions:

$$\text{Transformed value} = \frac{\text{value}^{\lambda} - 1}{\lambda}\text{ , if }\lambda \neq 0$$

$$\text{Transformed value} = \ln(\text{value})\text{ , if }\lambda = 0$$

The selected transformation was applied to all data (i.e., if piecewise modelling was used, a transformation selected based on Model 2 was also applied to MF3 data used in Model 3).

Following data transformation (if required), the selected models were fitted to the data. Statistical outliers were identified using studentized residuals with absolute values of 3.5 or greater, or due to consideration of leverage (where a single point could strongly influence the overall fit of the model). All values removed from analysis were retained for plots of model predictions, where they were presented using a different symbol from the rest of the data.

Following removal of outliers, breakpoint significance and data transformation was re-examined. Residuals from the refitted models were examined for normality, heteroscedasticity, and evidence of non-linear patterns. If non-linearity was evident from residual examination, the analysis was terminated and data were presented qualitatively. If residual assessments did not suggest that assumptions of linearity or residual normality were violated, then three models were constructed to assess the effect of heteroscedasticity for each response variable in each season:

- heteroscedasticity by gradient (applied only to Models 1 and 2)
- heteroscedasticity by predicted value (accounting for the classic trumpet shape of heteroscedastic data)
- heteroscedasticity by distance from the diffuser

These three models were compared to the original model that did not account for heteroscedasticity, using Akaike's information criterion (AIC), corrected for small sample size (AICc). The model with the lowest AICc score among a set of candidate models was interpreted to have the strongest support, given the set of examined models and the collected data (Burnham and Anderson 2002), and thus was selected for interpretation. When using AIC not corrected for small sample size, models with AIC scores within two units of each other are considered to have similar levels of support (Arnold 2010). Since the small sample size correction was used in the analysis, the cut-off value was adjusted to reflect the higher penalization of model parameters (the adjustment depended on the number of data points and model parameters).

The constructed models were used to produce the following outputs:

- Estimates and significance of slopes (i.e., distance effects) for each gradient. In the case of MF3 data analyzed using piecewise regression, the significance of the first slope, extending from the NF to the breakpoint, was estimated.
- The r^2 value of each model, to examine explained variability.
- Fitted prediction lines and 95% confidence intervals (back-transformed to original scale of the variable).

Based on US EPA (2000) guidance, a screening value of greater than 15% censoring was used to flag datasets that may not be amenable to the linear regression analysis. The decision of whether to analyze the data using linear regression was based on review of the number of values <DL for each variable and season. Because of a large number of values <DL, linear regression analysis was not performed for:

- TP: ice-cover (43% <DL) and open-water (65% <DL)
- TDP: ice-cover (92% <DL) and open-water (100% <DL)
- SRP: ice-cover (84% <DL) and open-water (91% <DL)
- nitrate: open-water (41% <DL)
- nitrite: ice-cover (32% <DL) and open-water (76% <DL)
- nitrate + nitrite: open-water (41% <DL)
- total ammonia: open-water (33% <DL in the ALS dataset)

Scatterplots of concentrations according to distance from the effluent discharge were included for variables that had large numbers of values that were <DL.

2.4.4.2 Normal Ranges

Magnitude of effects on indicators of eutrophication were evaluated by comparing nutrient concentrations, chlorophyll *a*, and phytoplankton and zooplankton biomass in the NF and MF areas to background values. Background values for Lac de Gras are those that fall within the range of natural variability, referred to as the normal range. Normal ranges were calculated using data from 2007 to 2010 (with some exceptions) and three AEMP FF areas (i.e., FF1, FFA, and FFB). The normal ranges used to evaluate potential effects for indicators of eutrophication were obtained from the *AEMP Reference Conditions Report Version 1.4* (Golder 2019a) and are summarized in Table 2-3.

Table 2-3 Normal Ranges for Eutrophication Indicators

Variable	Unit	Normal Range			
		Ice-cover		Open-water	
		Lower Limit	Upper Limit	Lower Limit	Upper Limit
Total phosphorus	µg-P/L	2.0	5.0	2.0	5.3
Total dissolved phosphorus	µg-P/L	1.1	3.2	0	3.5
Soluble reactive phosphorus	µg-P/L	0	1.5	0	1.0
Total nitrogen	µg-N/L	138	173	122	153
Total dissolved nitrogen	µg-N/L	130	166	105	133
Total ammonia	µg-N/L	11	17	0	6
Nitrate	µg-N/L	0	15.2	0	2.0
Nitrite	µg-N/L	0	2	0	2
Nitrate + nitrite	µg-N/L	5	10	0	1
Chlorophyll *a*	µg/L	-	-	0.31	0.82
Phytoplankton biomass	mg/m^3	-	-	19.1	385
Zooplankton biomass as AFDM	mg/m^3	-	-	16.4	40.5

Source: *AEMP Reference Conditions Report Version 1.4* (Golder 2019a).

AFDM = ash-free dry mass; µg-P/L = micrograms phosphorus per litre; µg-N/L = micrograms nitrogen per litre; mg/m^3 = milligrams per cubic metre; - = not applicable.

2.4.4.3 Extent of Effects

To estimate the extent of effects, the area of the lake with values greater than the normal range was estimated for TP, TN, chlorophyll *a*, and phytoplankton and zooplankton biomass. The extent of effects calculated for 2020 was compared with those estimated in previous years to evaluate whether effects were expanding farther into the lake over time.

Directive 2B from the 25 March 2019 WLWB Decision regarding the *AEMP 2017 Annual Report* (Golder 2018) directed DDMI to present the spatial extent of effects of eutrophication indicators for both the ice-covered and open-water seasons in future AEMP Annual Reports. Therefore, the extent of effects was calculated for both seasons. In addition, the extent of effects was calculated for all three depths (i.e., top, middle, and bottom) for the ice-covered season.

To quantify extent of effects along each transect, a linear interpolation method was used to estimate the distance between the station farthest from the diffuser with a value greater than the normal range, and the adjacent station with a value below the normal range. In cases where concentrations did not decrease uniformly with distance from the diffuser, a conservative approach was taken by assuming that the effect extended to the farthest station with a concentration above the normal range, even if closer stations along the transect had concentrations below the normal range.

2.4.4.4 Role of Nitrogen in Spatial Extent of Chlorophyll a

The 25 March 2019 WLWB Directive regarding the *2014 to 2016 Aquatic Effects Re-evaluation Report* required DDMI to include a spatial analysis of TN across the spatial extent of increased chlorophyll *a* in Lac de Gras. This directive was addressed in Section 5.3.5.3 of the *2014 to 2016 AEMP Re-evaluation Report Version 1.1* (Golder 2019b) and again in the *2017 to 2019 Aquatic Effects Re-evaluation Report* (Golder 2020b) using data available for all AEMP monitoring years up to 2019. To address this recommendation during an interim sampling year, relationships among these variables were evaluated in the 2020 open-water dataset by calculating Pearson correlation coefficients.

2.4.4.5 Effects from Dust Deposition

Concerns have been raised regarding the potential for dust emissions from the Mine to affect nutrient enrichment in Lac de Gras. To address these concerns, the following analyses have been presented:

- **Calculation of annual TP loads from dust deposition to Lac de Gras**. Consistent with methods in previous AEMP reports (e.g., *AEMP 2019 Annual Report*, Golder 2020c), the relative magnitudes of phosphorus delivered to Lac de Gras in 2020 from natural (i.e., background) and anthropogenic (Mine-related) dust deposition were estimated using data from the 2020 dustfall monitoring program. The annual TP load from dust was compared to the TP load from effluent, with the caveat that the dust program was not designed to be as precise as effluent monitoring for measuring TP loads to Lac de Gras; findings from this analysis should be considered along with the other lines of evidence as described below.
- **Visual comparison of open-water TP and chlorophyll *a* concentrations within the estimated zone of influence (ZOI) from dust deposition to results at other nearby stations outside the ZOI, and to reference conditions for Lac de Gras (i.e., normal range)**. Based on the analysis conducted for the last re-evaluation, the dust ZOI is estimated to extend between 3.7 and 4.8 km from the geographic centre of the Mine (i.e., the Mine centroid), or between 0.3 and 4.2 km from the boundary of the Mine footprint (Golder 2020b). These distances were estimated based on gradient analysis of dust deposition relative to distance from the Mine site and encompass the area of the lake where potential effects would be expected to be measurable (Golder 2020b). Beyond this estimated zone, dust deposition levels are similar to background levels. The AEMP sampling stations that fall within the expected zone of influence (ZOI) from dust deposition include the five stations in the NF area and stations MF1-1, MF3-1, MF3-2 and MF3-3[3].
- **Summary of the *Special Effects Study – Dust Deposition* (Dust SES; Appendix XI to the *AEMP 2019 Annual Report* [Golder 2020c])**. The Dust SES sampled stations that were located closer to the potentially high dust generating areas than the AEMP stations noted above that are within the dust ZOI. Also, the Dust SES identified the geochemical signatures of Mine effluent and dustfall and evaluated the fate of dust-related phosphorus in lake water.

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[3] Formerly, Station MF2-1 was considered within the dust ZOI; with the revised dust ZOI delineated in the *2017 to 2019 Aquatic Effects Re-evaluation Report* (Golder 2020b), this station is no longer expected to be measurably affected by dust. Station MF3-3 is now within the dust ZOI.

- **Summary of the spatial-temporal analysis and comparison of phosphorus deposition rates and phosphorus concentrations in Lac de Gras at the end of the ice-cover season from the *2017 to 2019 Aquatic Effects Re-evaluation Report* (Golder 2020b)**. During spring break-up, the entire winter dust load that accumulated on lake ice is delivered to lake water over a short period, resulting in the maximum potential dust-related increase in phosphorus concentration in lake water within a typical year. The re-evaluation analysis provided estimated increases in TP and SRP concentrations in lake water at spring break-up within and outside the dust ZOI, using dust deposition estimates and lake water chemistry data accumulated over the last decade of monitoring.

2.5 Action Level Evaluation

The magnitude of effects on selected assessment endpoints was categorized according to the Action Level framework described for indicators of eutrophication in the *AEMP Design Plan Version 4.1* (Golder 2017a). The Action Level classifications were developed to meet the goals of the draft *Guidelines for Adaptive Management – A Response Framework for Aquatic Effects Monitoring* (WLWB 2010) and Racher et al. (2011). The main goal of the Response Framework is to ensure that significant adverse effects never occur. This is accomplished by requiring proponents to take actions at predefined Action Levels, which are triggered well before significant adverse effects could occur.

The Significance Threshold for the indicators of eutrophication is a concentration of chlorophyll *a* that exceeds the Effects Threshold by more than 20% in the FFA area of Lac de Gras (Table 2-4; Golder 2017a). In contrast to linking toxicological impairment responses to water chemistry (e.g., from elevated concentrations of metals), eutrophication responses are difficult to link to nutrient concentrations. As demonstrated by years of monitoring in Lac de Gras, concentrations of TP do not predict the actual biological response to nutrient enrichment. Rather, the increase in the biomass of algae as measured by chlorophyll *a* has been a useful measure of the effects of nutrient enrichment.

Elevated concentrations of nutrients were predicted in Lac de Gras (Government of Canada 1999). Specifically, up to 20% (i.e., 116 km^2) of the surface area of Lac de Gras was expected to exceed the EA Benchmark for phosphorus during peak operations during the open-water season, and up to 11% (i.e., 64 km^2) of the lake during the ice-cover season. Outside these areas, TP concentration was predicted to increase relative to baseline in parts of Lac de Gras, but concentrations would remain below the EA Benchmark. The “extent of effect” for the chlorophyll *a* Action Levels reflects this prediction (Table 2-4).

A box-and-whisker plot was generated for chlorophyll *a* to present the 2020 results relative to Action Level threshold values.

Table 2-4 Action Levels for Chlorophyll *a*

Action Level	Magnitude of Effect	Extent of Effect	Action/Notes
1	95th percentile of MF values greater than normal range(a)	MF station	Early warning.
2	NF and MF values greater than normal range(a)	20% of lake area or more	Establish Effects Benchmark.
3	NF and MF values greater than normal range plus 25% of Effects Benchmark(b)	20% of lake area or more	Confirm site-specific relevance of existing benchmark. Establish Effects Threshold.
4	NF and MF values greater than normal range plus 50% of Effects Threshold(c)	20% of lake area or more	Investigate mitigation options.
5	NF and MF values greater than Effects Threshold	20% of lake area or more	The WLWB to re-assess EQC for phosphorus. Implement mitigation required to meet new EQC if applicable.
6	NF and MF values greater than Effects Threshold +20%	20% of lake area or more	The WLWB to re-assess EQC for phosphorus. Implement mitigation required to meet new EQC if applicable.
7	95th percentile of MF values greater than Effects Threshold +20%	All MF stations	The WLWB to re-assess EQC for phosphorus. Implement mitigation required to meet new EQC if applicable.
8	95th percentile of FFB values greater than Effects Threshold +20%	FFB	The WLWB to re-assess EQC for phosphorus. Implement mitigation required to meet new EQC if applicable.
9(d)	95th percentile of FFA values greater than Effects Threshold+20%	FFA	Significance Threshold(d).

a) The normal range for chlorophyll *a* was obtained from the *AEMP Reference Conditions Report Version 1.4* (Golder 2019a).

b) Indicates 25% of the difference between the Effects Benchmark and the top of the normal range.

c) Indicates 50% of the difference between the Effects Threshold and the top of the normal range.

d) Although the Significance Threshold is not an Action Level, it is shown as the greatest Action Level to demonstrate escalation of effects towards the Significance Threshold.

NF = near-field; MF = mid-field; FF = far-field; WLWB = Wek'èezhìı Land and Water Board; EQC = Effluent Quality Criteria.

Given that Action Level 2 for chlorophyll *a* has been triggered in previous years (Golder 2016a,b, 2017c), an Effects Benchmark for chlorophyll *a* was developed as part of *AEMP Study Design Version 3.5* (Golder 2014). The chlorophyll *a* Effects Benchmark concentration of 4.5 µg/L is appropriate in terms of both the aesthetic quality and food web functionality in Lac de Gras. Aesthetic qualities are likely to be preserved at chlorophyll *a* concentrations up to 10 µg/L, while a benchmark of 4.5 µg/L maintains the trophic classification of the lake as oligotrophic (Golder 2017a).

3 RESULTS

3.1 Effluent and Mixing Zone

Monthly loads of TP generally followed concentrations in effluent with larger loads in May and June, while effluent concentrations were greatest between April and June (Figure 3-1). During the open-water season, the magnitude of the monthly loads continued to follow the effluent concentrations and did not appear to follow effluent volume (i.e., NITWP flow). Concentrations at the mixing zone boundary also largely followed effluent concentrations, with greater concentrations in April and May; June samples at the mixing zone boundary could not be collected due to hazardous ice conditions.

The monthly TP load did not exceed the 300 kg/mo loading criterion, with the greatest monthly load of TP (63 kg) occurring in May 2020. The annual TP load in 2020 (289 kg) was below the average annual loading criterion of 1,000 kg defined in the Water Licence (W2015L2-0001; WLWB 2015), and much lower than the maximum annual loading criterion of 2,000 kg. The annual TP load in 2020 was comparable to the annual TP load in 2019 (279 kg).

Monthly loads of TDP did not follow the same pattern as TP, in that monthly TDP loads were more similar during the ice-cover season and did not exhibit the same increase in May and June that TP did. However, lower TDP loads generally occurred in the open-water season compared to the ice-cover season, with the exception of August, which followed the magnitude of TDP in effluent (i.e., concentrations in effluent were generally lower during the open-water season; Figure 3-2). Concentrations of TDP at the mixing zone boundary were generally at the DL or greater, with more detectable concentrations measured during December, January, July and October. The concentrations of TDP at the mixing zone did not follow the same pattern as the effluent concentrations; mixing zone concentrations were generally lower during the ice-cover season compared to the open-water season, while effluent concentrations showed the reverse.

For SRP, monthly loads and concentrations in effluent followed a similar pattern to TP but with lower loads during the open-water season compared to the ice-cover season. Concentrations of TDP at the effluent and at the mixing zone boundary followed a similar pattern (Figure 3-3).

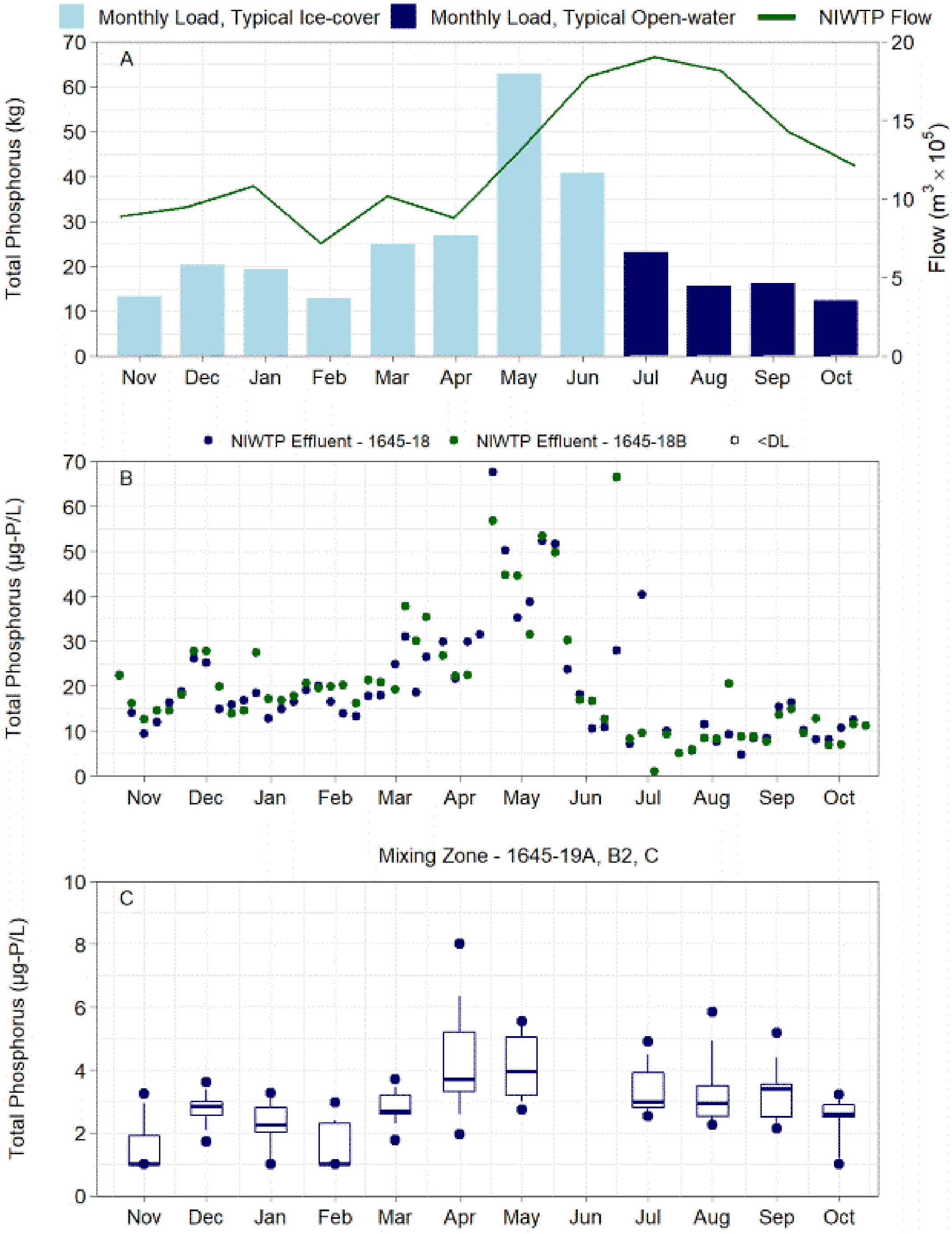
All species of nitrogen had concentrations and loads in effluent that tracked closely together and followed a similar trend to effluent volume (Figure 3-4 to Figure 3-7). Monthly TN loads were similar or greater in 2020 compared to 2019. Most of the TN was present as nitrate in the effluent (Figure 3-4 and Figure 3-5). Monthly loads and concentrations of TN and nitrate in effluent were smallest during the ice-cover season and gradually increased from April to August (Figure 3-4 and Figure 3-5). Median TN and nitrate concentrations at the mixing zone boundary were approximately equal between seasons, with slightly lower concentrations during the open-water season and the lowest median concentrations in August (Figure 3-4 and Figure 3-5).

Monthly loads and concentrations of nitrite in effluent followed the same pattern as for TN and nitrate, but with less of a decline from August to October (Figure 3-6). Concentrations in effluent declined from August to September, and monthly load in October reflected the greater concentrations in effluent. Nitrite concentrations at the mixing zone boundary followed the pattern in effluent, except in July and August when mixing zone boundary concentrations were lower.

Total ammonia monthly loads and concentrations in effluent did not follow the same pattern as the other nitrogen species. Loads generally followed effluent volume for most months (Figure 3-7). Concentrations in effluent were greatest in June, with a steady increase from April to June and a step-like decline from June to October. The smallest monthly load was in April, at a different time from the lowest effluent concentrations, which occurred in June and September. Concentrations at the mixing zone boundary generally followed those in effluent, except in the open-water season when the mixing zone concentrations were low and the effluent concentrations were variable.

The decreases in concentrations of TN, nitrate, nitrite, and total ammonia between July and August at the mixing zone boundary (Figure 3-4 to Figure 3-7) reflects quick assimilation by algae and bacterial nitrification (Wetzel 2001) during the shift between the seasons.

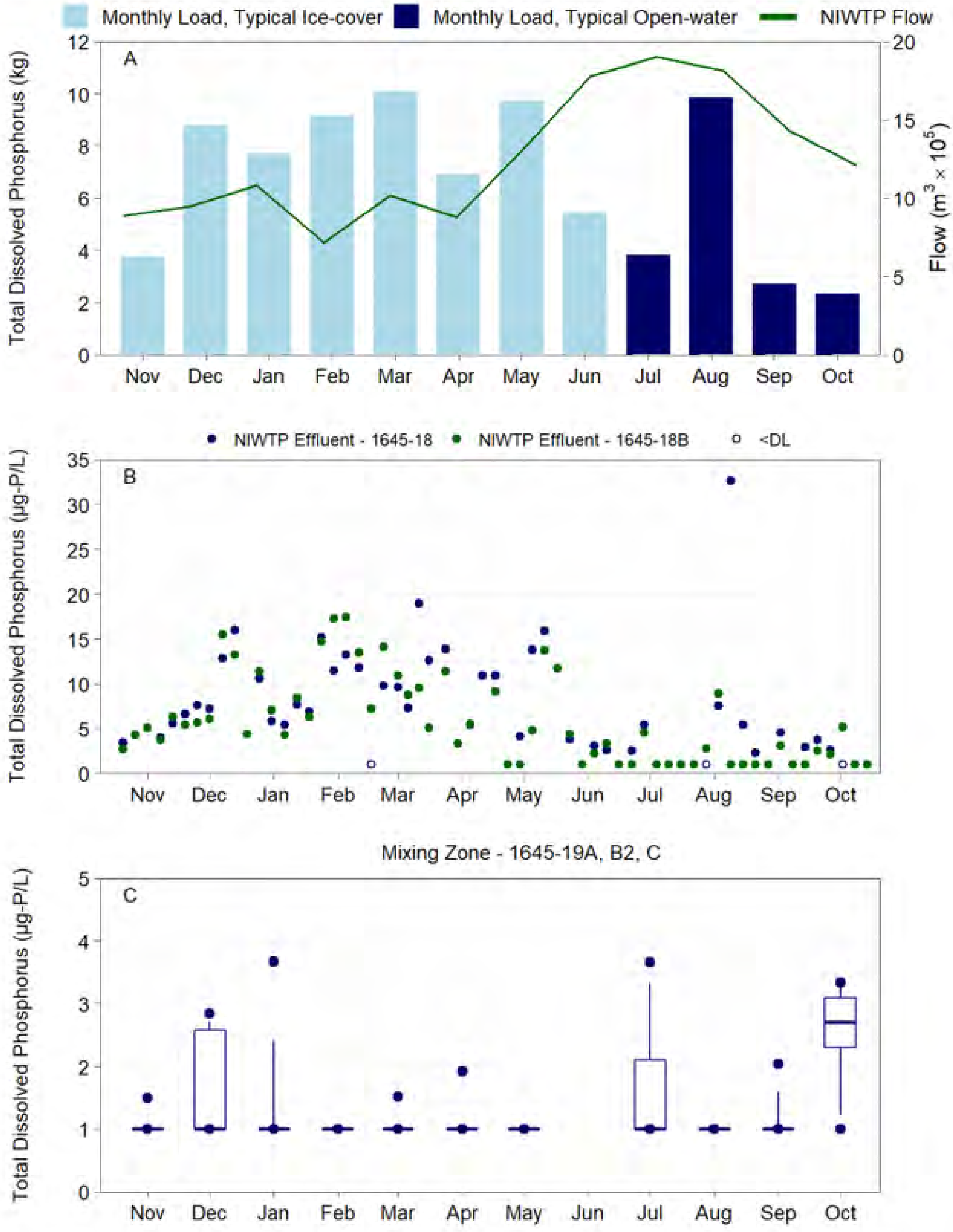
Figure 3-1 **Total Phosphorus: A) Monthly Loads in the Effluent, B) Concentrations in the Effluent, C) at the Mixing Zone Boundary, November 2019 to October 2020**



Notes: Concentrations in effluent are for individual samples. Mixing zone values represent the monthly 5th percentile, median, and 95th percentile concentrations at three stations (1645-19A, 1645-19B2, 1645-19C) and five depths (2 m, 5 m, 10 m, 15 m and 20 m). The mixing zone samples could not be collected in June 2020 due to hazardous ice conditions. Boxplots represent the 10th, 25th, 50th (i.e., median), 75th, and 90th percentile concentrations in each sampling area. The black dots in the boxplots represent the 5th (on the bottom) and 95th (on the top) percentiles.

µg-P/L = micrograms phosphorus per litre; NIWTP = North Inlet Water Treatment Plant.

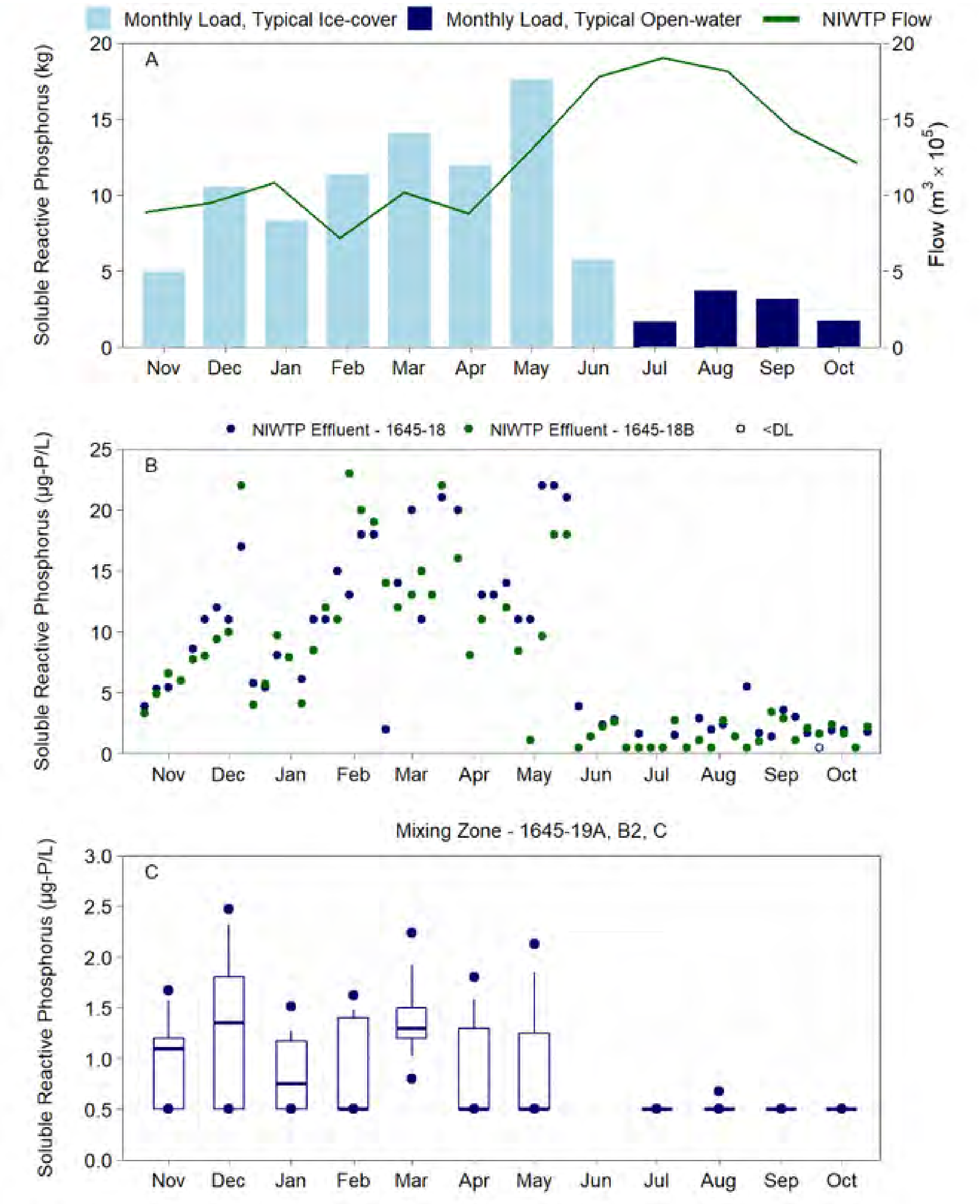
Figure 3-2 Total Dissolved Phosphorus: A) Monthly Loads in the Effluent, B) Concentrations in the Effluent, C) at the Mixing Zone Boundary, November 2019 to October 2020



Notes: Concentrations in effluent are for individual samples. Mixing zone values represent the monthly 5th percentile, median, and 95th percentile concentrations at three stations (1645-19A, 1645-19B2, 1645-19C) and five depths (2 m, 5 m, 10 m, 15 m and 20 m). The mixing zone samples could not be collected in June 2020 due to hazardous ice conditions. Boxplots represent the 10th, 25th, 50th (i.e., median), 75th, and 90th percentile concentrations in each sampling area. The black dots in the boxplots represent the 5th (on the bottom) and 95th (on the top) percentiles.

µg-P/L = micrograms phosphorus per litre; NIWTP = North Inlet Water Treatment Plant; <DL = less than detection limit.

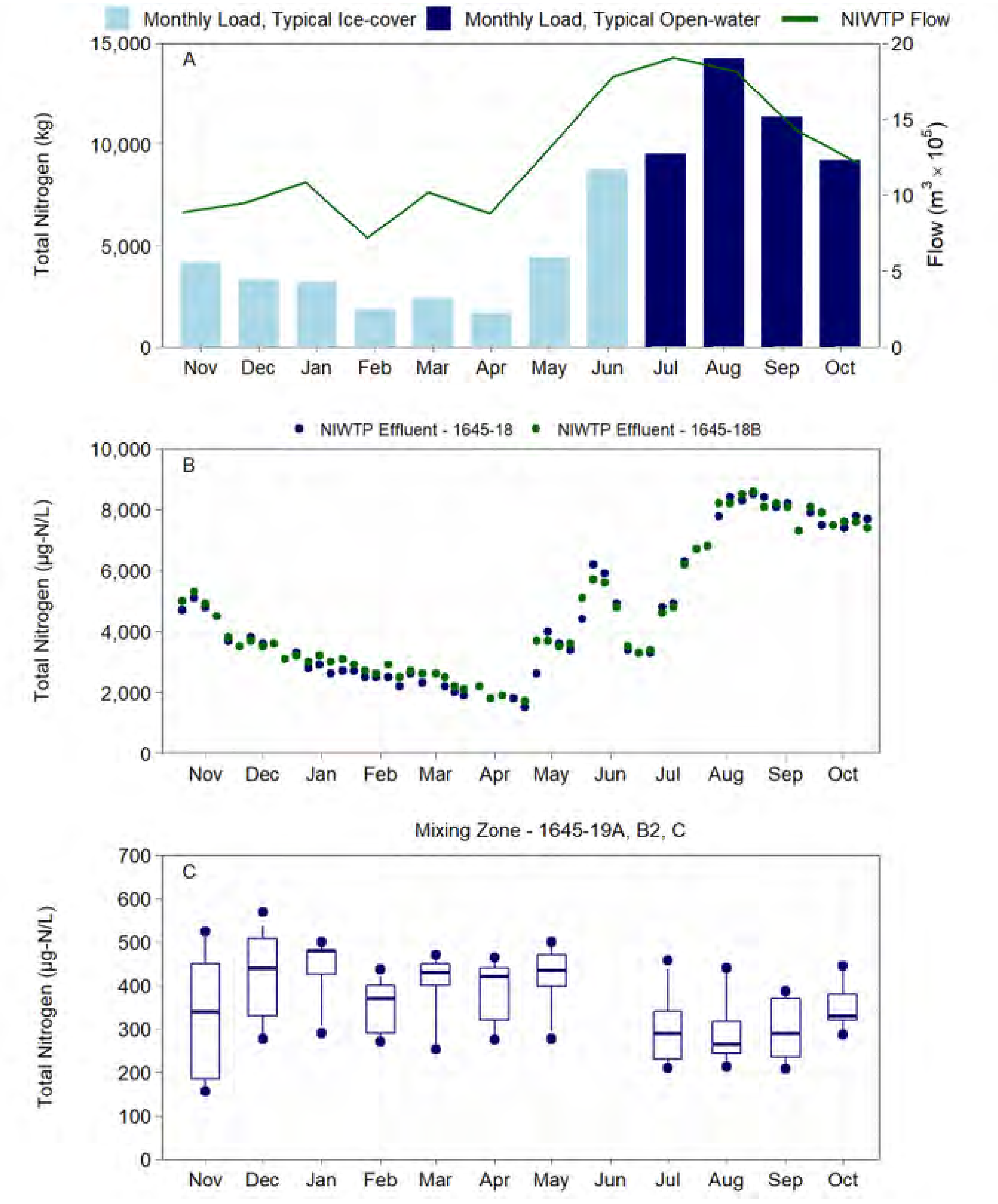
Figure 3-3 Soluble Reactive Phosphorus: A) Monthly Loads in the Effluent, B) Concentrations in the Effluent, C) at the Mixing Zone Boundary, November 2019 to October 2020



Notes: Concentrations in effluent are for individual samples. Mixing zone values represent the monthly 5th percentile, median, and 95th percentile concentrations at three stations (1645-19A, 1645-19B2, 1645-19C) and five depths (2 m, 5 m, 10 m, 15 m and 20 m). The mixing zone samples could not be collected in June 2019 due to hazardous ice conditions. Boxplots represent the 10th, 25th, 50th (i.e., median), 75th, and 90th percentile concentrations in each sampling area. The black dots in the boxplots represent the 5th (on the bottom) and 95th (on the top) percentiles.

µg-P/L = micrograms phosphorus per litre; NIWTP = North Inlet Water Treatment Plant; <DL = less than detection limit.

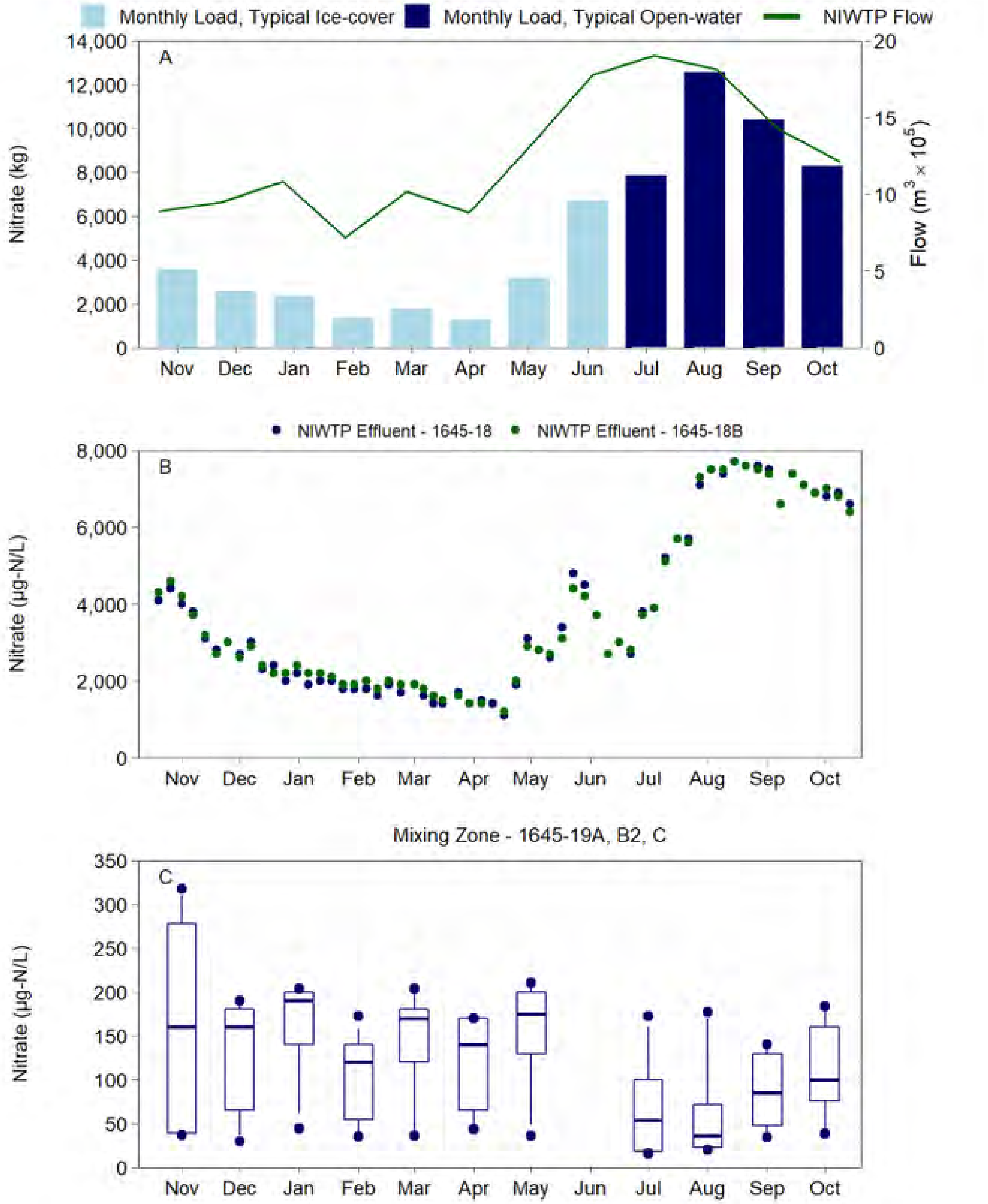
Figure 3-4 **Total Nitrogen: A) Monthly Loads in the Effluent, B) Concentrations in the Effluent, C) at the Mixing Zone Boundary, November 2019 to October 2020**



Notes: Concentrations in effluent are for individual samples. Mixing zone values represent the monthly 5th percentile, median, and 95th percentile concentrations at three stations (1645-19A, 1645-19B2, 1645-19C) and five depths (2 m, 5 m, 10 m, 15 m and 20 m). The mixing zone samples could not be collected in June 2020 due to hazardous ice conditions. Boxplots represent the 10th, 25th, 50th (i.e., median), 75th, and 90th percentile concentrations in each sampling area. The black dots in the boxplots represent the 5th (on the bottom) and 95th (on the top) percentiles.

µg-N/L = micrograms nitrogen per litre; NIWTP = North Inlet Water Treatment Plant.

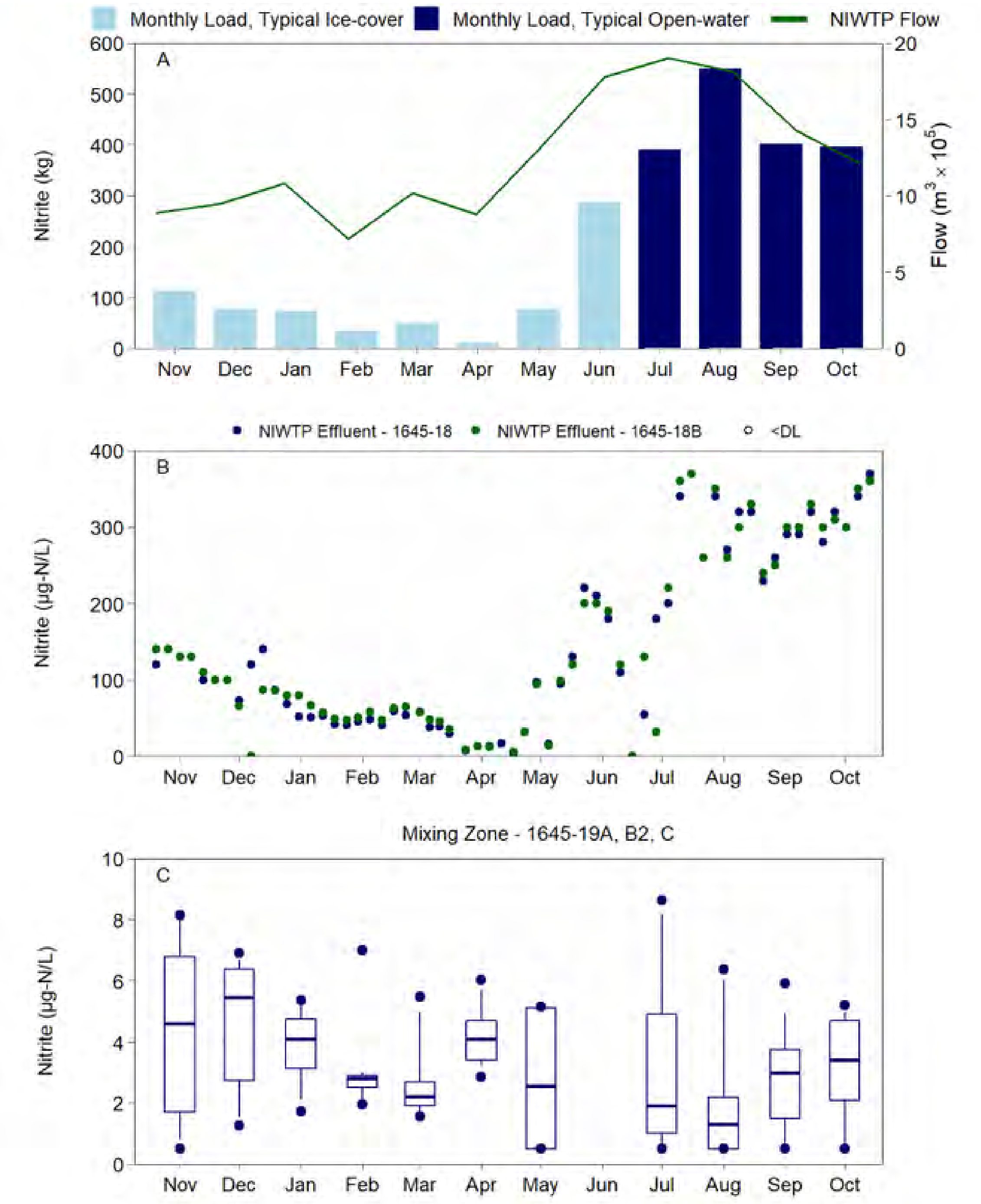
Figure 3-5 **Nitrate: A) Monthly Loads in the Effluent, B) Concentrations in the Effluent, C) at the Mixing Zone Boundary, November 2019 to October 2020**



Notes: Concentrations in effluent are for individual samples. Mixing zone values represent the monthly 5th percentile, median, and 95th percentile concentrations at three stations (1645-19A, 1645-19B2, 1645-19C) and five depths (2 m, 5 m, 10 m, 15 m and 20 m). The mixing zone samples could not be collected in June 2020 due to hazardous ice conditions. Boxplots represent the 10th, 25th, 50th (i.e., median), 75th, and 90th percentile concentrations in each sampling area. The black dots in the boxplots represent the 5th (on the bottom) and 95th (on the top) percentiles.

µg-N/L = micrograms nitrogen per litre; NIWTP = North Inlet Water Treatment Plant.

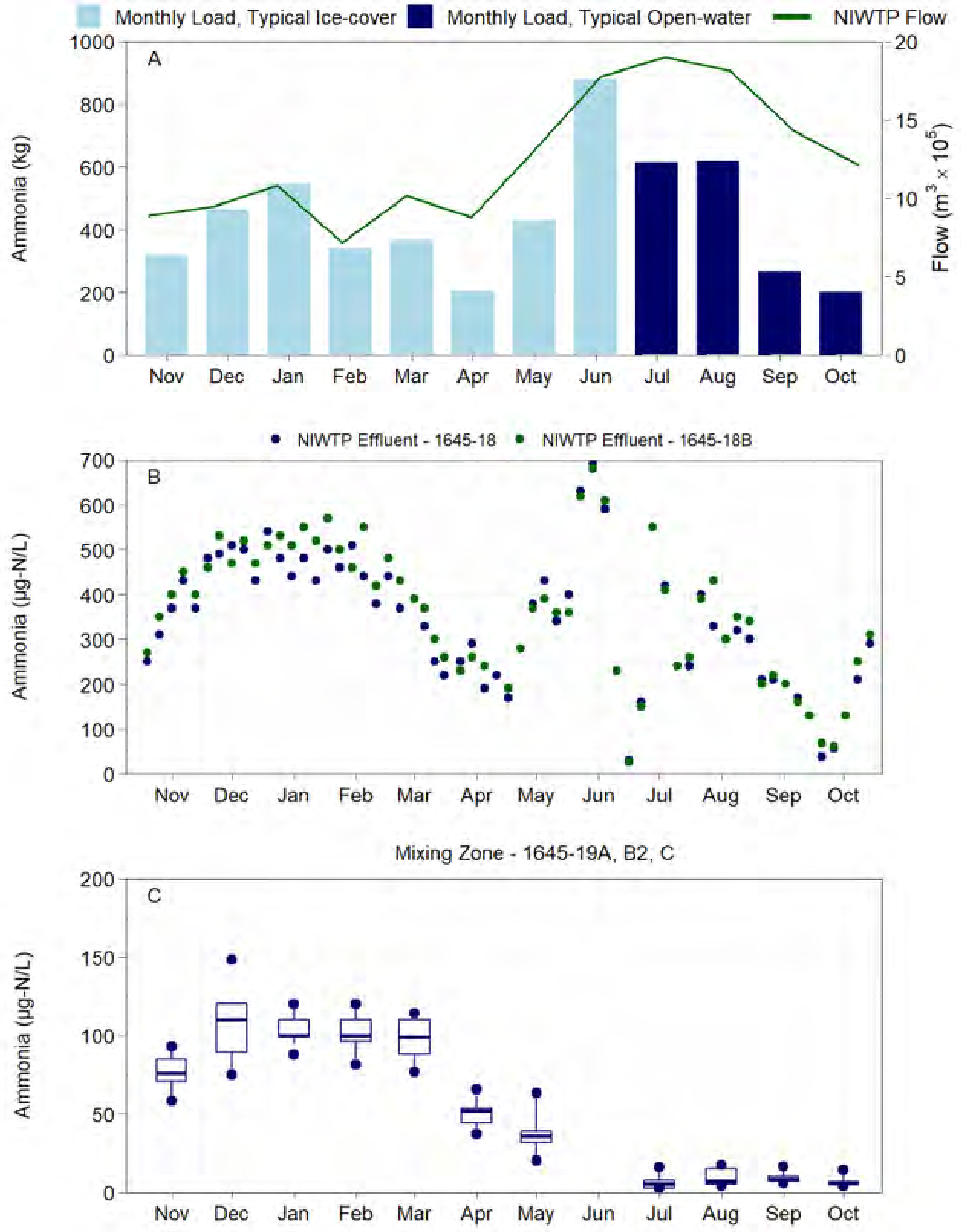
Figure 3-6 **Nitrite: A) Monthly Loads in the Effluent, B) Concentrations in the Effluent, C) at the Mixing Zone Boundary, November 2019 to October 2020**



Notes: Concentrations in effluent are for individual samples. Mixing zone values represent the monthly 5th percentile, median, and 95th percentile concentrations at three stations (1645-19A, 1645-19B2, 1645-19C) and five depths (2 m, 5 m, 10 m, 15 m and 20 m). The mixing zone samples could not be collected in June 2020 due to hazardous ice conditions. Boxplots represent the 10th, 25th, 50th (i.e., median), 75th, and 90th percentile concentrations in each sampling area. The black dots in the boxplots represent the 5th (on the bottom) and 95th (on the top) percentiles.

µg-N/L = micrograms nitrogen per litre; NIWTP = North Inlet Water Treatment Plant; <DL = less than detection limit.

Figure 3-7 Total Ammonia: A) Monthly Loads in the Effluent, B) Concentrations in the Effluent, C) at the Mixing Zone Boundary, November 2019 to October 2020



Notes: Concentrations in effluent are for individual samples. Mixing zone values represent the monthly 5th percentile, median, and 95th percentile concentrations at three stations (1645-19A, 1645-19B2, 1645-19C) and five depths (2 m, 5 m, 10 m, 15 m and 20 m). The mixing zone samples could not be collected in June 2020 due to hazardous ice conditions. Boxplots represent the 10th, 25th, 50th (i.e., median), 75th, and 90th percentile concentrations in each sampling area. The black dots in the boxplots represent the 5th (on the bottom) and 95th (on the top) percentiles.

µg-N/L = micrograms nitrogen per litre; NIWTP = North Inlet Water Treatment Plant.

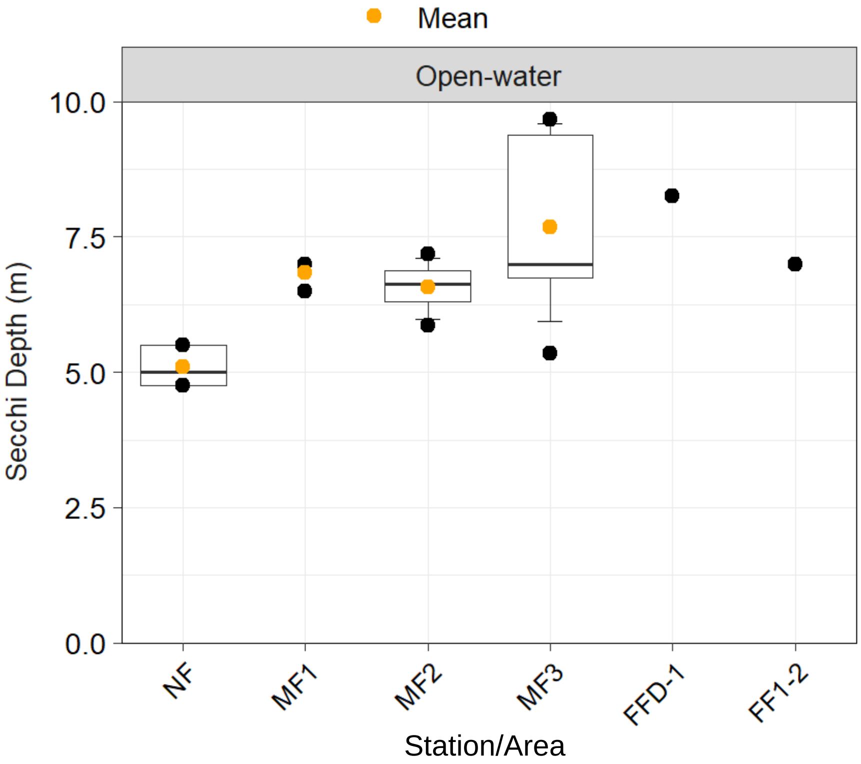
3.2 Lac de Gras

3.2.1 Secchi Depth

The Secchi depth corresponds to the depth at which approximately 10% of surface light remains (Dodds and Whiles 2010). The euphotic zone extends to a depth where approximately 1% of surface light remains, often estimated as twice the Secchi depth (Dodds and Whiles 2010). In less productive (i.e., oligotrophic) waterbodies like Lac de Gras, with low amounts of suspended or dissolved material, light is transmitted to greater depths (Dodds and Whiles 2010). Secchi depth data are useful to estimate the extent of the euphotic zone where sufficient light is available for phytoplankton, and provide an indirect measure of algal biomass in the water column.

Secchi depth measurements indicated good light penetration throughout Lac de Gras. Secchi depth was between 4.75 and 9.75 m during the open-water season in 2020 (Figure 3-8). Mean Secchi depth was highest in the MF3 area (7.7 m), although the single measurement at FFD-1 (8.25 m) was greater, and was lowest in the NF area (5.1 m), consistent with the expectation of greater algal turbidity in this area due to nutrient enrichment. Given the Secchi depths measured in Lac de Gras, a large proportion of the total volume of this lake is within the euphotic zone and can support phytoplankton growth.

Figure 3-8 Secchi Depth in Lac de Gras during the Open-Water Season, 2020



Notes: Secchi depth was not measured at LDS-4 and LDG-48 stations. Boxplots represent the 10th, 25th, 50th (i.e., median), 75th, and 90th percentile concentrations in each sampling area. The black dots in the boxplots represent the 5th (on the bottom) and 95th (on the top) percentiles, except in cases with three or less data points, where the reported values are shown.

LDS = Lac du Sauvage; NF = near-field; MF = mid-field; FF = far-field; LDG-48 = Lac de Gras outlet.

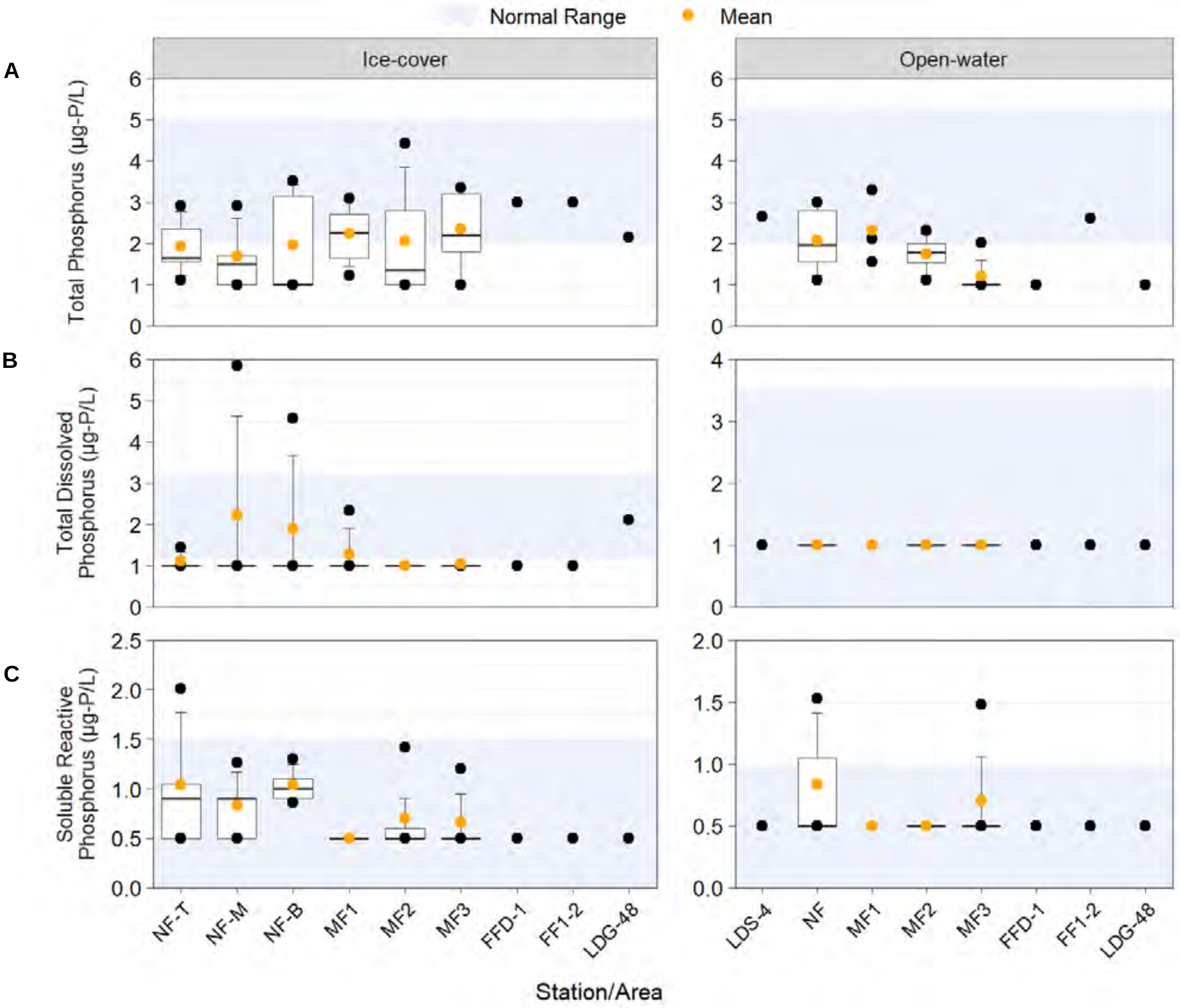
3.2.2 Nutrients

Concentrations of TP were within or below normal range at all stations during the ice-cover and open-water seasons (Figure 3-9A). During the ice-cover season, TP concentrations were highest at FFD-1 and FF1-2, and lowest, on average, at the NF mid-depth (Figure 3-9A). Concentrations during open-water were frequently <DL of 2 µg-P/L in other areas. During the open-water season, TP concentrations were generally highest in the NF and MF1 areas and at LDS-4 and FF1-2, and generally <DL in all other areas, including at LDG-48 (Figure 3-9A).

Similar to TP, TDP concentrations were infrequently detected during both the ice-cover and open-water seasons. During the ice-cover season, all detected concentrations were within or below the normal range with the exception of NF2 at the mid and bottom depths (Figure 3-9B). As noted in Section 2.3, the TDP results for the NF2 mid and bottom depths during the ice-cover season are suspected to be biased high. Concentrations of TDP were greater than the corresponding TP concentration for the NF2 station at these two depths (Figure 3-9). During the open-water season, all detected concentrations were within the normal range at all stations (Figure 3-9B). Concentration of TDP at LDG-48 was within the normal range for both the ice-cover and the open-water seasons (Figure 3-9B).

In contrast to TP and TDP, concentrations of SRP were more frequently detected due to its lower DL (1 µg/L for SRP compared to 2 µg/L for TP and TDP). However, concentrations were low (i.e., within five times the DL). The SRP concentrations were generally within the normal range, with the highest concentrations reported in the NF area during both seasons (Figure 3-9C).

Figure 3-9 **Concentrations of Total Phosphorus (A), Total Dissolved Phosphorus (B), and Soluble Reactive Phosphorus (C) in Lac de Gras during the Ice-Cover and Open-Water Season, 2020**



Notes: Boxplots represent the 10th, 25th, 50th (i.e., median), 75th, and 90th percentile concentrations in each sampling area. The black dots in the boxplots represent the 5th (on the bottom) and 95th (on the top) percentiles, except in cases with three or less data points, where the reported values are shown. Non-detect values are plotted at half detection limit.

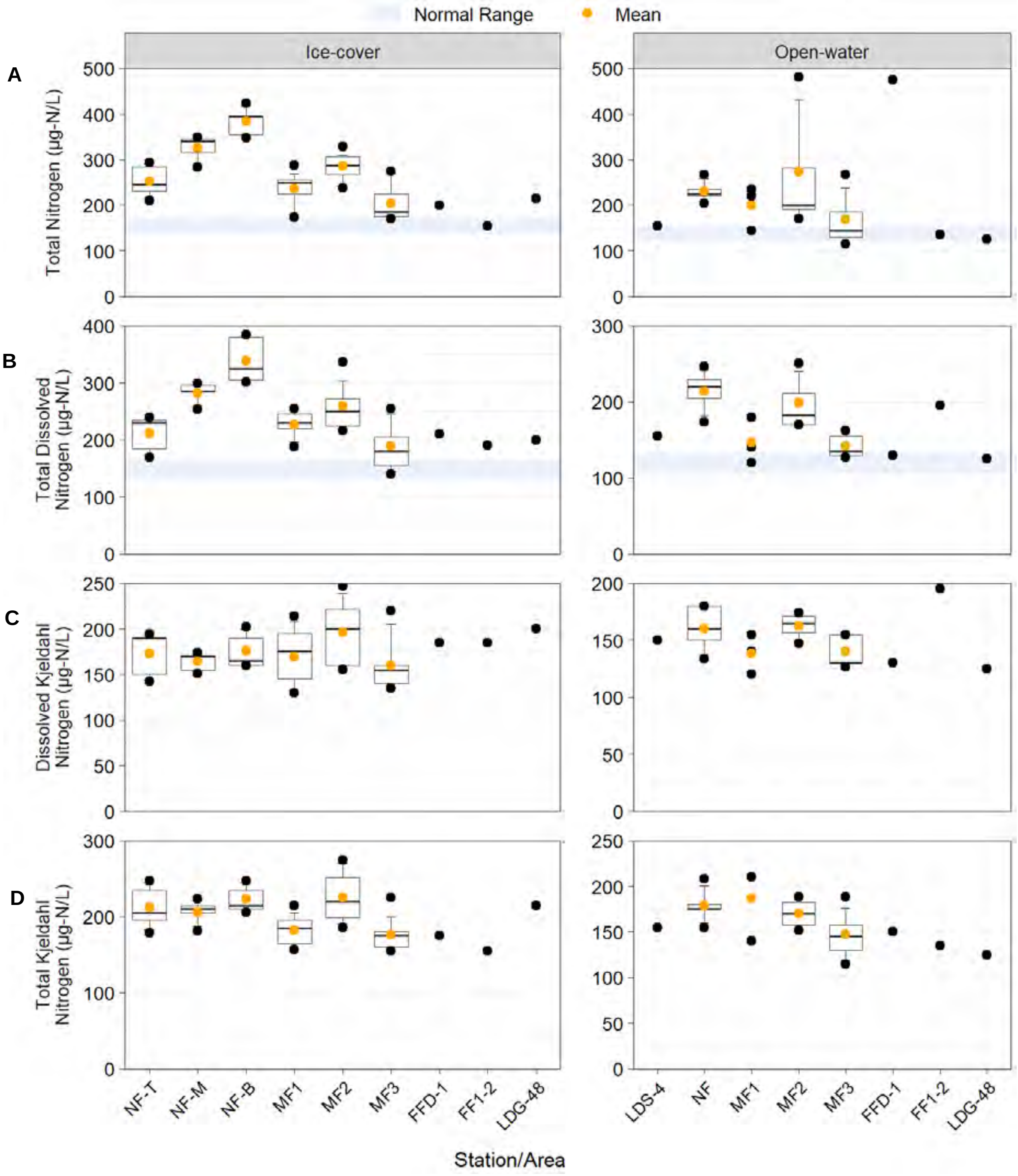
µg-P/L = micrograms phosphorus per litre; LDS-4 = Lac du Sauvage outlet (the Narrows); NF = near-field; MF = mid-field; FF = far-field; LDG-48 = Lac de Gras outlet; T = top depth; M = middle depth; B = bottom depth.

Concentrations of TN and TDN in the NF area were greater during the ice-cover season than during open-water (Figure 3-10A,B). During the ice-cover season, TN and TDN concentrations increased with depth in the NF area, reflecting the discharge of effluent to the bottom of the water column. Concentrations of TN and TDN were generally at or above the normal range, with the highest concentrations in the NF area. During the open-water season, TN concentrations were similar between the NF, MF1, and MF2 areas. Concentrations of TN and TDN at LDS-4 were similar to those in the MF1 and MF3 areas during the open-water season. As noted in Section 2.3, the reported TN concentration at FFD-1 during the open-water season was much greater than the other nitrogen species, particularly TKN; this value was, therefore, likely inaccurate.

Concentrations of TKN and DKN generally followed the same patterns as TN and TDN, respectively, with a less noticeable variation by depth in the NF area during the ice-cover season (Figure 3-10C,D).

During the ice-cover and open-water seasons, TN, TDN, TKN, and DKN concentrations at LDG-48 were similar to mean concentrations in the MF3 area, with the exception of TKN and DKN during ice-cover, where concentrations were comparable to the NF area (Figure 3-10).

Figure 3-10 **Concentrations of Total Nitrogen (A), Total Dissolved Nitrogen (B), Dissolved Kjeldahl Nitrogen (C), and Total Kjeldahl Nitrogen (D) in Lac de Gras during the Ice-Cover and Open-Water Season, 2020**



Notes: Boxplots represent the 10th, 25th, 50th (i.e., median), 75th, and 90th percentile concentrations in each sampling area. The black dots in the boxplots represent the 5th (on the bottom) and 95th (on the top) percentiles, except in cases with three or less data points, where the reported values are shown.

µg-N/L = micrograms nitrogen per litre; LDS-4 = Lac du Sauvage outlet (the Narrows); NF = near-field; MF = mid-field; FF = far-field; LDG-48 = Lac de Gras outlet; T = top depth; M = middle depth; B = bottom depth.

Nitrate and nitrate + nitrite concentrations followed the same pattern as TN and TDN, with concentrations increasing with depth in the NF area during the ice-cover season (Figure 3-11A,C). Concentrations decreased with distance from the diffuser. Most concentrations were greater than the normal range. Concentrations of nitrate, nitrite, and nitrate + nitrite were not detected during the ice-cover and open-water seasons at LDG-48. Nitrate, nitrite, and nitrate + nitrite concentrations at LDS-4 were either not detected, or slightly above the DL during the open-water season.

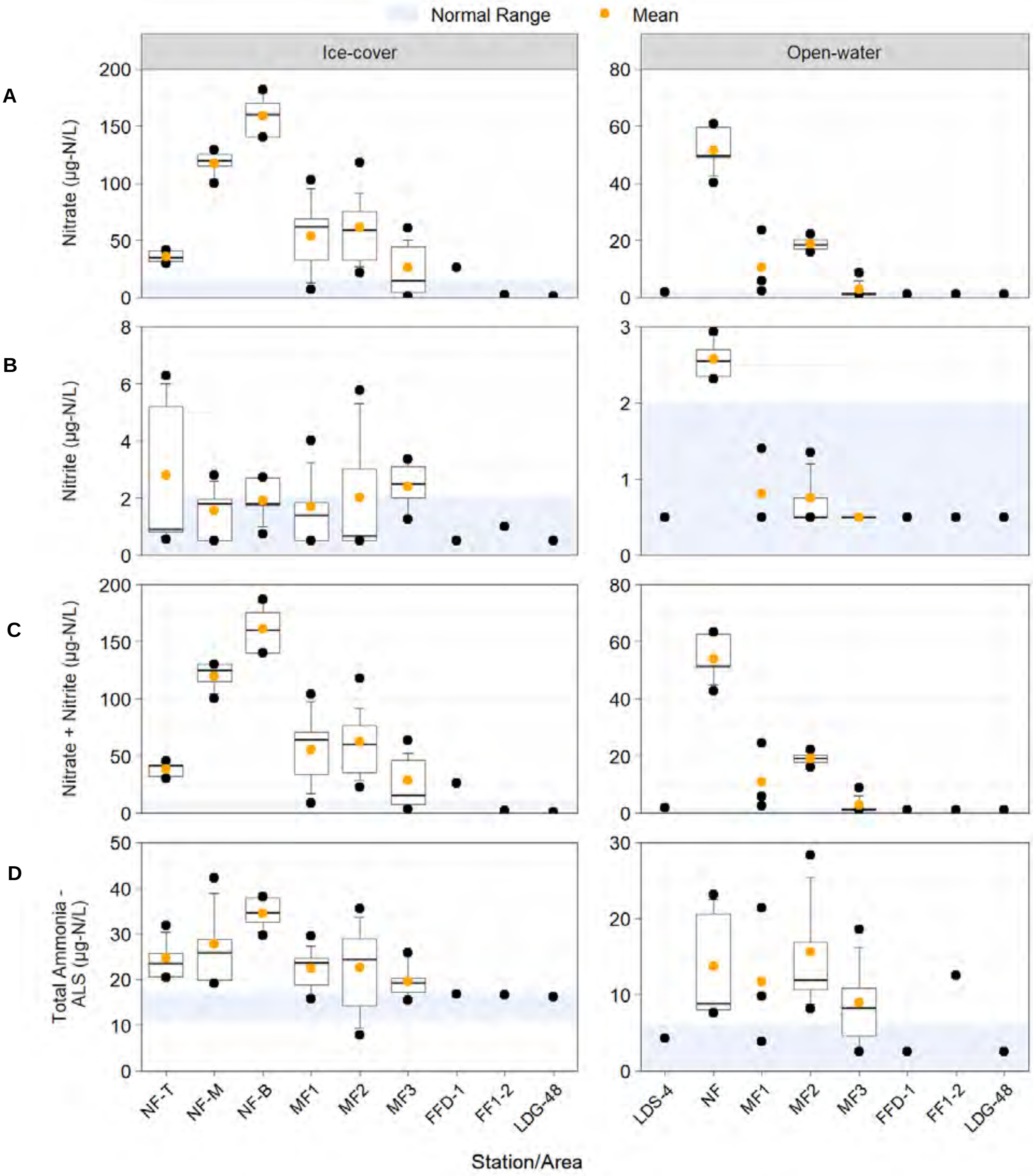
As with TN, TDN, and total ammonia, nitrate concentrations were substantially greater during the ice-cover season compared to the open-water season. This pattern is commonly observed, because concentrations decline as algae assimilate the dissolved nutrients for growth during the open-water season (Wetzel 2001).

Nitrite concentrations were much lower than nitrate concentrations, and did not follow the same pattern. Nitrite concentrations during the ice-cover season were similar among depths in the NF area, and comparable to the MF areas (Figure 3-11B). During the ice-cover season, the mean nitrite concentration in the MF2 and MF3 areas were above the normal range, and concentrations at FFD-1 and FF1-2 were within the normal range. Most nitrite concentrations were within five times the DL of 1 µg-N/L. During the open-water season, all nitrite concentrations were at or near the DL and within the normal range except for the NF area, where all concentrations were above the normal range (Figure 3-11B). Nitrite was not detected in either season at LDS-4 and LDG-48.

Total ammonia concentrations followed a similar pattern as nitrate (Figure 3-11D). Most total ammonia concentrations were greater than the normal range during both the ice-cover and open-water seasons. At LDS-4, open-water concentrations were generally below those in the NF and MF areas but were similar to FFD-1 and LDG-48 concentrations. Total ammonia concentrations at LDG-48 during the ice-cover season were below those in the MF and FF areas, and were comparable to FFD-1 and FF1-2.

Concentrations of SRSi during the ice-cover season increased with depth in the NF area. Concentrations measured at the mid and bottom depths in the NF area were noticeably greater than all other areas, while the concentrations at the NF area top depth were similar to those in all other areas (Figure 3-12). Concentrations during the open-water season were lower in all areas and more variable, with greater concentrations in the NF area and LDS-4 compared to the MF areas, and the FFD-1, FF1-2 and LDG-48 stations. The highest concentration during the open-water season was measured at LDS-4. The measured SRSi concentration at LDG-48 during the ice-cover season was comparable to the FFD-1 and FF1-2 stations, while the open-water concentration was similar to the MF2 area.

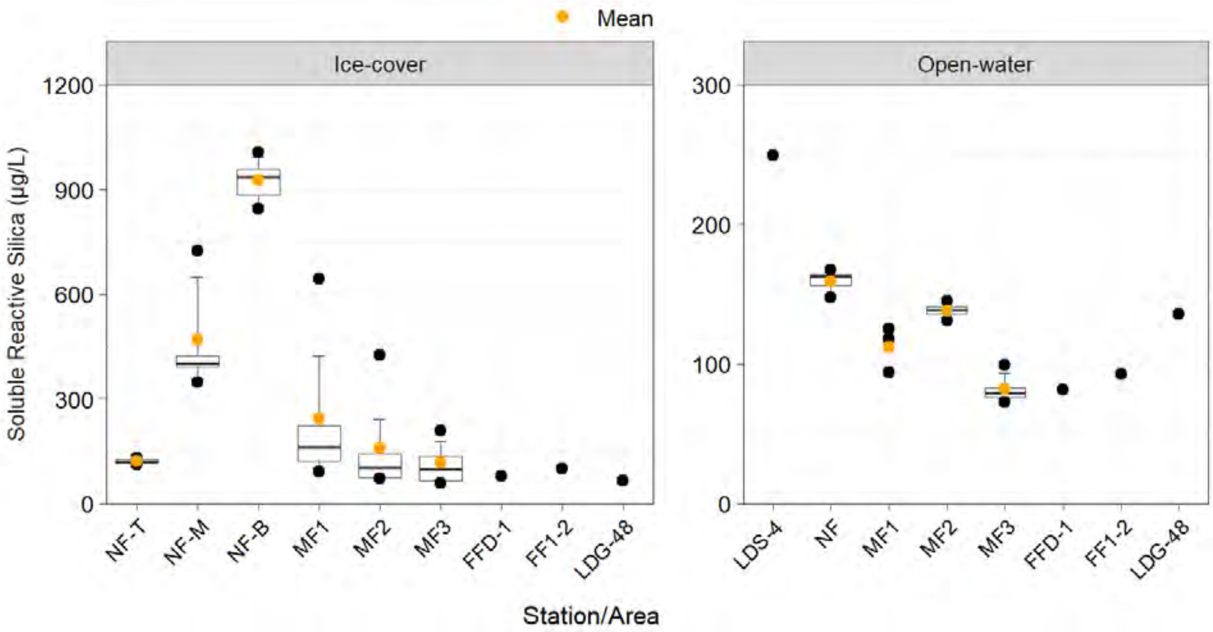
Figure 3-11 Concentrations of Nitrate (A), Nitrite (B), Nitrate + Nitrite (C) and Total Ammonia (D) in Lac de Gras during the Ice-Cover and Open-Water Season, 2020



Notes: Boxplots represent the 10th, 25th, 50th (i.e., median), 75th, and 90th percentile concentrations in each sampling area. The black dots in the boxplots represent the 5th (on the bottom) and 95th (on the top) percentiles, except in cases with three or less data points, where the reported values are shown. Non-detect values are plotted at half detection limit.

µg-N/L = micrograms nitrogen per litre; LDS-4 = Lac du Sauvage outlet (the Narrows); NF = near-field; MF = mid-field; FF = far-field; LDG-48 = Lac de Gras outlet; T = top depth; M = middle depth; B = bottom depth.

Figure 3-12 Concentrations of Soluble Reactive Silica in Lac de Gras during the Ice-Cover and Open-Water Season, 2020



Notes: Boxplots represent the 10th, 25th, 50th (median), 75th, and 90th percentile concentrations in each sampling area. The black dots in the boxplots represent the 5th (on the bottom) and 95th (on the top) percentiles, except in cases with three or less data points, where the reported values are shown.

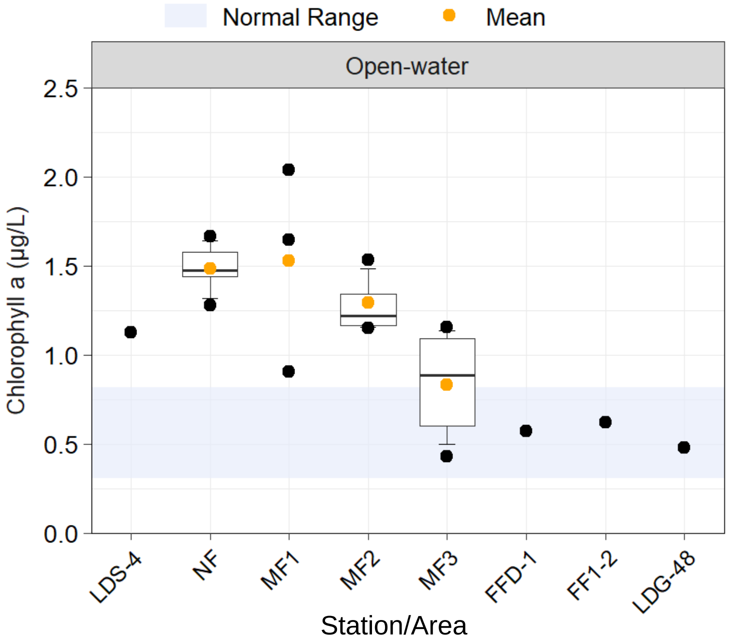
µg/L = micrograms per litre; LDS-4 = Lac du Sauvage outlet (the Narrows); NF = near-field; MF = mid-field; FF = far-field; LDG-48 = Lac de Gras outlet; T = top depth; M = middle depth; B = bottom depth.

3.2.3 Chlorophyll *a*, and Phytoplankton and Zooplankton Biomass

Chlorophyll *a* concentration was used as an indicator of phytoplankton standing crop (i.e., biomass) in Lac de Gras during the open-water season. Ice and snow reduce the amount of light entering the lake to a fraction of surface solar radiation; consequently, algal growth under ice-cover is limited by light and temperature, resulting in low chlorophyll *a* concentrations. Therefore, chlorophyll *a* concentration is not measured at AEMP stations during the ice-cover season.

Mean chlorophyll *a* concentrations in Lac de Gras exceeded the normal range in the NF and MF areas and at the Lac de Sauvage outlet (LDS-4; Figure 3-13). Concentrations of chlorophyll *a* show a decreasing trend with distance from the diffuser, with some stations in the MF3 area remaining within the normal range. The concentrations measured at FFD-1, FF1-2, and LDG-48 were similar and within the normal range. The lowest chlorophyll *a* concentrations were measured in the MF3 area and at LDG-48. The maximum chlorophyll *a* concentration measured in 2020 in the MF1 area was approximately half of the Effect Threshold value of 4.5 µg/L.

Figure 3-13 Chlorophyll *a* Concentrations in Lac de Gras during the Open-Water Season, 2020



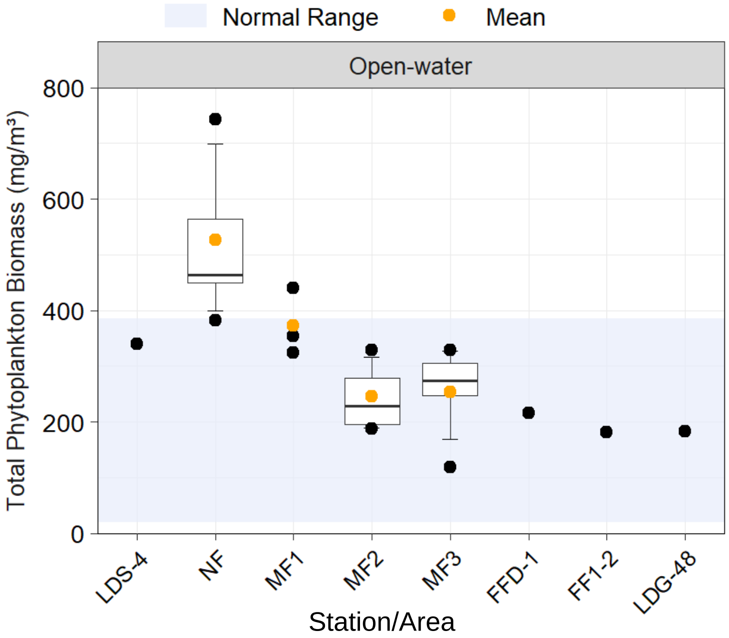
Notes: Boxplots represent the 10th, 25th, 50th (i.e., median), 75th, and 90th percentile concentrations in each sampling area. The black dots in the boxplots represent the 5th (on the bottom) and 95th (on the top) percentiles, except in cases with three or less data points, where the reported values are shown.

µg/L = micrograms per litre; LDS-4 = Lac du Sauvage outlet (the Narrows); NF = near-field; MF = mid-field; FF = far-field; LDG-48 = Lac de Gras outlet.

Total phytoplankton biomass exceeded the normal range in the NF area and at station MF1-3; all other stations were within the normal range (Figure 3-14). Total phytoplankton biomass decreased with distance from the diffuser.

Mean zooplankton biomass (as AFDM) in all areas was above the normal range, with some stations in the MF3 area falling within the normal range (Figure 3-15). Zooplankton biomass in the NF, MF1, and MF2 areas was greater than in the MF3 area, and at stations FFD-1 and FF1-2.

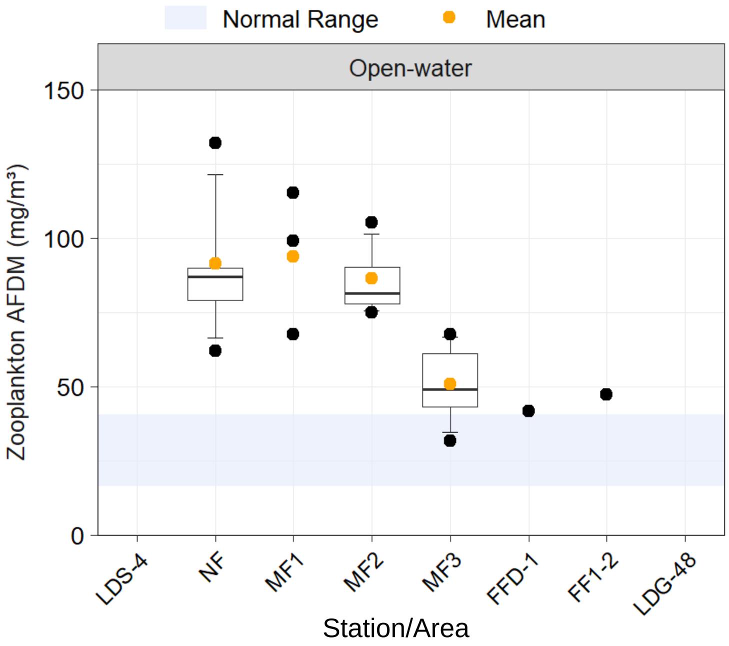
Figure 3-14 Total Phytoplankton Biomass in Lac de Gras during the Open-Water Season, 2020



Notes: Boxplots represent the 10th, 25th, 50th (i.e., median), 75th, and 90th percentile concentrations in each sampling area. The black dots in the boxplots represent the 5th (on the bottom) and 95th (on the top) percentiles, except in cases with three or less data points, where the reported values are shown.

mg/m^3 = milligrams per cubic metre; NF = near-field; MF = mid-field; FF = far-field; LDG-48 = Lac de Gras outlet; LDS-4 = Lac du Sauvage outlet (the Narrows).

Figure 3-15 Total Zooplankton Biomass (as AFDM) in Lac de Gras during the Open-Water Season, 2020



Notes: Zooplankton is not measured at LDS-4 and LDG-48. Boxplots represent the 10th, 25th, 50th (i.e., median), 75th, and 90th percentile concentrations in each sampling area. The black dots in the boxplots represent the 5th (on the bottom) and 95th (on the top) percentiles, except in cases with three or less data points, where the reported values are shown.

An error by the analytical laboratory resulted in an aliquot being removed in error from most sample bottles prior analysis of zooplankton biomass. An investigation determined the bias was low (i.e., <2% decrease in biomass) and, therefore, the results were not corrected for this bias.

AFDM = ash-free dry mass; mg/m^3 = milligrams per cubic metre; LDS-4 = Lac du Sauvage outlet (the Narrows); NF = near-field; MF = mid-field; FF = far-field; LDG-48 = Lac de Gras outlet.

3.2.4 Percent Change from Baseline and Previous Year

Per Directive 2D from the 25 March 2019 WLWB Decision regarding the *AEMP 2017 Annual Report* (Golder 2018), percent change values from the baseline median and the previous year (i.e., 2019) median value were calculated for each eutrophication indicator, by area (i.e., NF, MF1, MF2, MF3, and LDG-48) and season (i.e., ice-cover and open-water; Attachment D Tables D-1 to D-10). The results indicate that median values of eutrophication indicators have generally increased in the NF area relative to baseline (Table D-1 and Table D-6), consistent with EA predictions and interpretation of AEMP data during annual reporting. Further discussion of these results is provided in Attachment D.

3.2.5 Gradient Analysis

3.2.5.1 Secchi Depth

Secchi depth along all MF transects appeared to increase with increasing distance from the effluent discharge (Figure 3-16), which is consistent with reduced Secchi depth due to greater phytoplankton biomass in the water column closer to the diffusers, as also shown by phytoplankton biomass (i.e., biovolume) results and chlorophyll *a* concentrations. The slope of the regression line was significantly different from zero for the MF1 and MF3 transects, but not for the MF2 transect (Table 3-1).

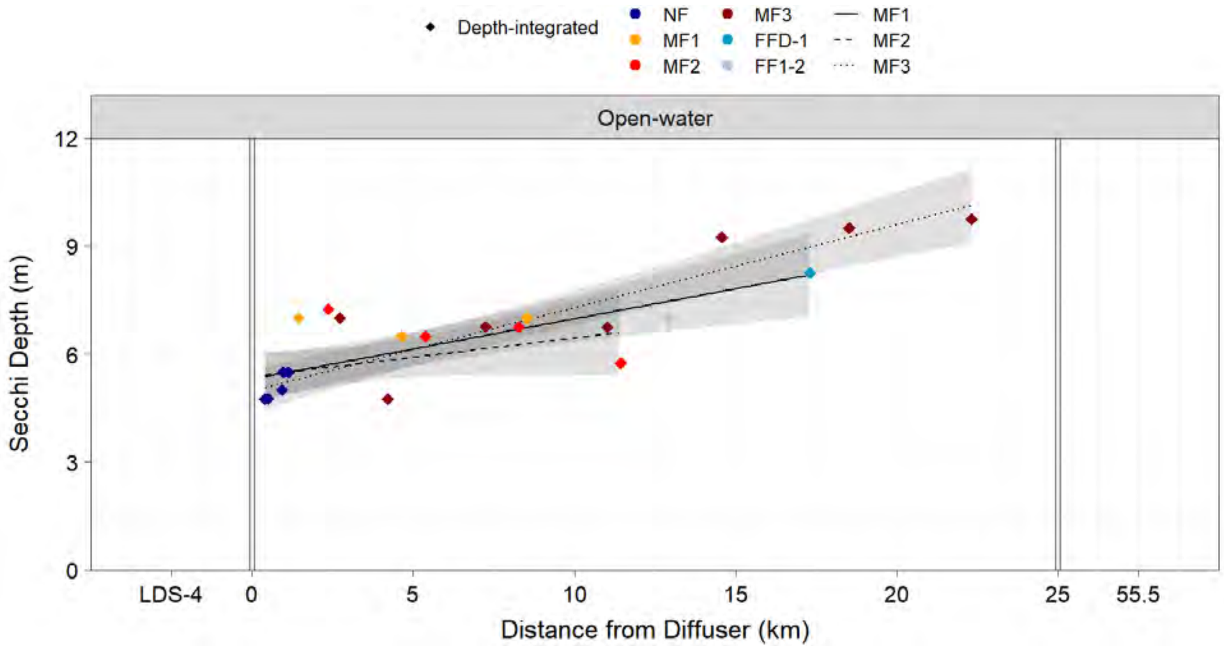
Table 3-1 Gradient Analysis Results for Secchi Depth during the Open-water Season, 2020

Variable	Model	Transformation[(a)]	Gradient	Slope[(a)]	*P*-value	R^2
Secchi Depth	Model 1	-	MF1	↑	<0.001	0.74
			MF2	↑	0.118	
			MF3	↑	<0.001	

a) Slope direction was represented by an upward arrow (↑) indicating an increasing trend with distance from the effluent diffusers, or a downward arrow (↓) indicating a decreasing trend with distance from the effluent diffusers.

- = not applicable; MF = mid-field; *P* = probability; R^2 = coefficient of determination.

Figure 3-16 Secchi Depth in Lac de Gras According to Distance from the Effluent Discharge, 2020

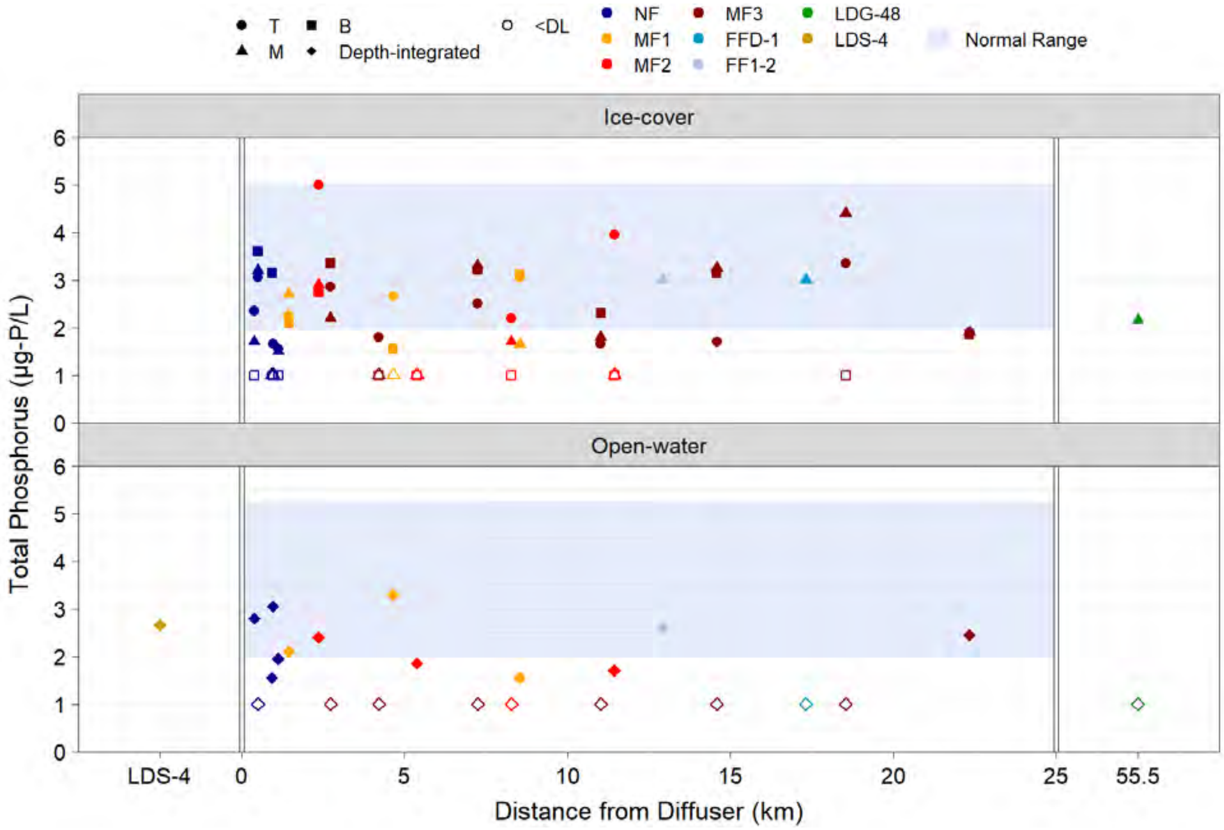


Note: Secchi depth is not measured at LDS-4 and LDG-48.
NF = near-field; MF = mid-field; FF = far-field; LDS-4 = Lac du Sauvage outlet (the Narrows).

3.2.5.2 Nutrients

During the ice-cover and open-water seasons, TP concentrations were within or below the normal range at all stations (Figure 3-17). Gradient analysis was not done for TP because of the low detection frequency. During the ice-cover season, TP concentration was variable with no apparent gradient trend. During the open-water season, a slight declining trend in TP concentration was apparent with increasing distance from the diffusers. The concentration of TP at LDS-4 during the open-water season was comparable to the NF area, while TP concentrations at LDG-48 during both seasons were at or slightly above DL.

Figure 3-17 Concentrations of Total Phosphorus in Lac de Gras and Lac du Sauvage According to Distance from the Effluent Discharge, 2020

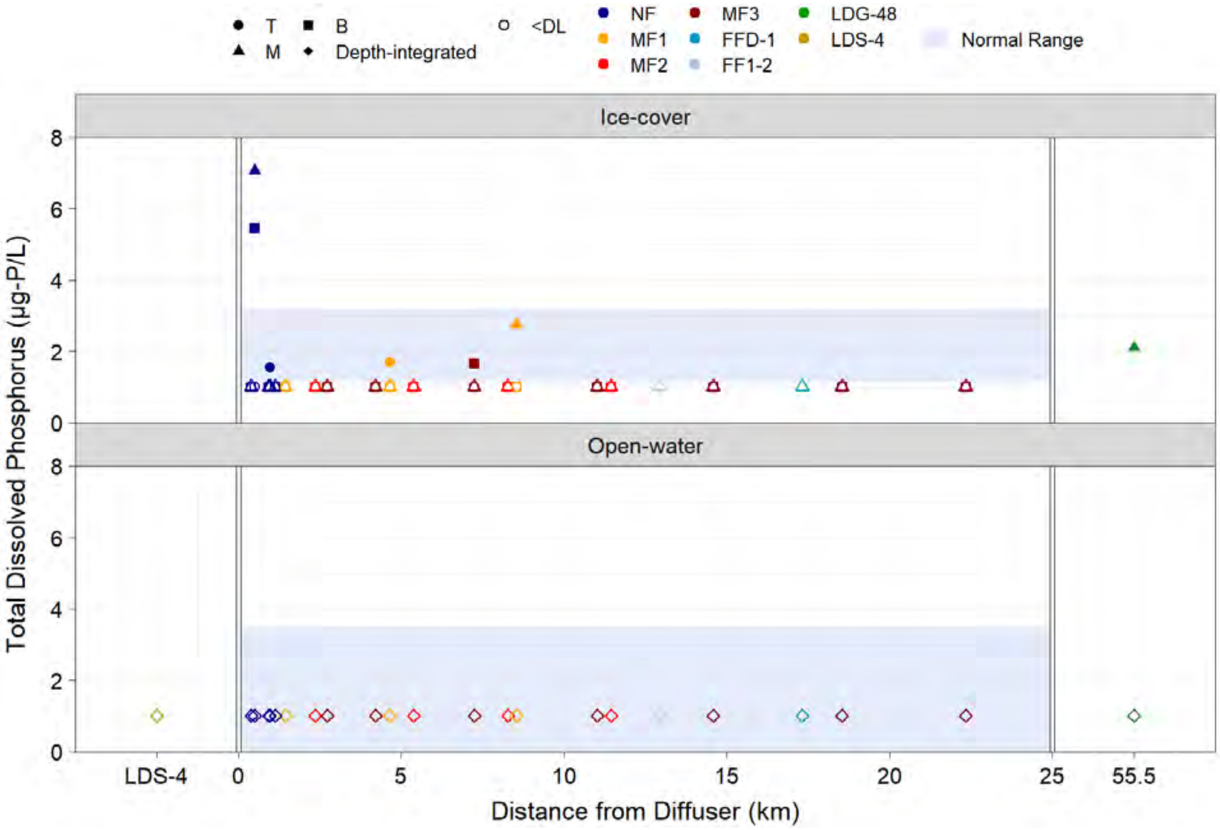


Note: LDS-4 and LDG-48 results are presented in separate panels, to the left and right of the y-axis, respectively. Station LDS-4 was not sampled during ice-cover season.

µg-P/L = micrograms phosphorus per litre; T = top depth; M = middle depth; B = bottom depth; <DL = less than detection limit; NF = near-field; MF = mid-field; FF = far-field; LDG-48 = Lac de Gras outlet; LDS-4 = Lac du Sauvage outlet (the Narrows).

Concentrations of TDP during the ice-cover season were within or below the normal range at nearly all stations, except for those at NF2 mid and bottom depths (Figure 3-18). Section 2.3 discusses the QC issues associated with these samples. During the open-water season, all TDP concentrations were <DL. Gradient analysis was not done for TDP for both seasons because of the low detection frequency. Visual evaluation of TDP during the ice-cover season shows slight variation in the detectable results with no apparent gradient trend.

Figure 3-18 Concentrations of Total Dissolved Phosphorus in Lac de Gras and Lac du Sauvage According to Distance from the Effluent Discharge, 2020

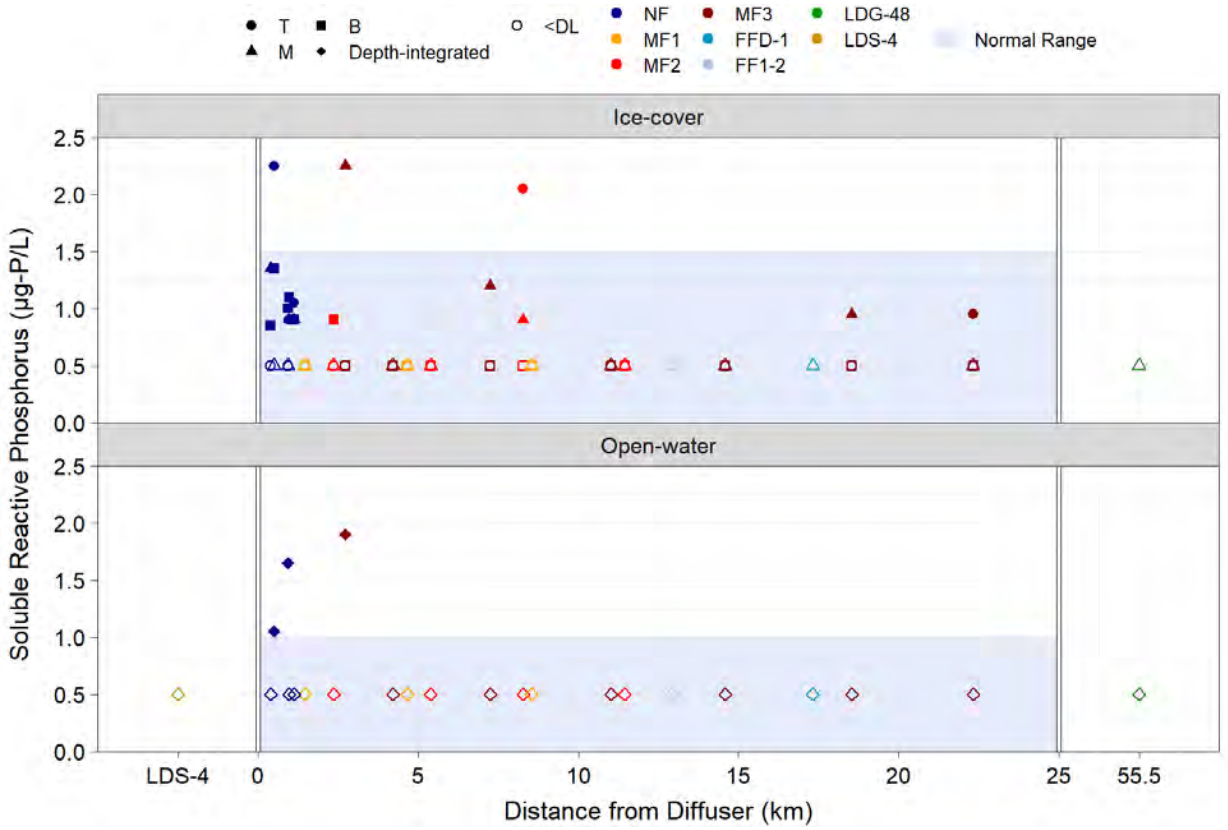


Note: LDS-4 and LDG-48 results are presented in separate panels, to the left and right of the y-axis, respectively. Station LDS-4 was not sampled during ice-cover season.

µg-P/L = micrograms phosphorus per litre; T = top depth; M = middle depth; B = bottom depth; <DL = less than detection limit; NF = near-field; MF = mid-field; FF = far-field; LDG-48 = Lac de Gras outlet; LDS-4 = Lac du Sauvage outlet (the Narrows).

Concentrations of SRP during the ice-cover season were generally within the normal range at most of the stations (Figure 3-19). During the open-water season, SRP concentrations were not detectable, with the exception of one or two stations in the MF3 and NF areas, respectively (Figure 3-19). Gradient analysis was not done for SRP in under-ice and open-water conditions because of the low detection frequency. Visual evaluation of the data during both ice-cover and open-water seasons suggested a decreasing trend with distance from the diffusers, as more concentrations were detectable in the NF area relative to all other areas.

Figure 3-19 Concentrations of Soluble Reactive Phosphorus in Lac de Gras and Lac du Sauvage According to Distance from the Effluent Discharge, 2020

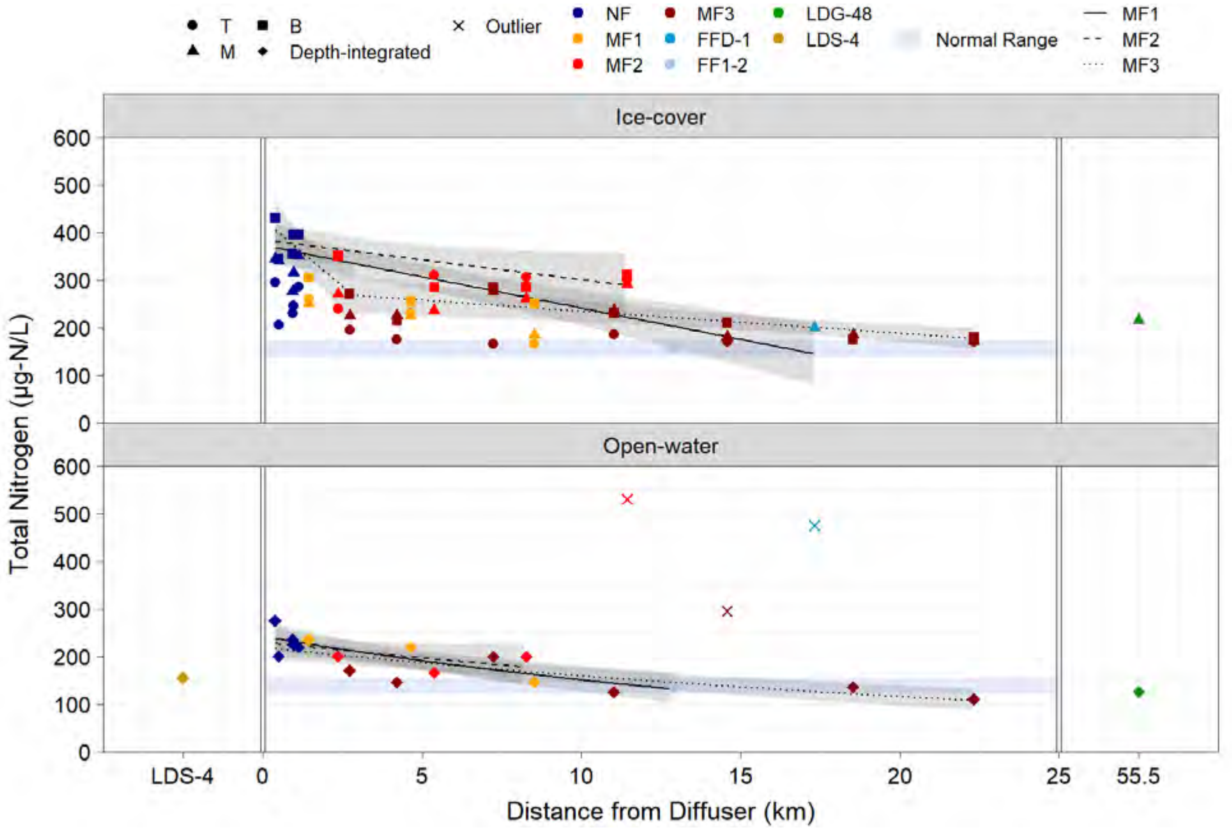


Note: LDS-4 and LDG-48 results are presented in separate panels, to the left and right of the y-axis, respectively. Station LDS-4 was not sampled during ice-cover season.

µg/L = micrograms per litre; NF = near-field; MF = mid-field; FF = far-field; T = top depth; M = middle depth; B = bottom depth; <DL = less than detection limit; LDG-48 = Lac de Gras outlet; LDS-4 = Lac du Sauvage outlet (the Narrows).

Concentrations of TN were generally greater than the normal range during both ice-cover and open-water seasons (Figure 3-20). Significant decreasing trends in TN concentrations were observed along all transects during both seasons, except in the MF2 transect during open-water conditions where the *P*-value was not significant (Table 3-2). Similar results were observed for TDN, except that no significant trend was observed for MF2 transect during ice-cover conditions (Figure 3-21 and Table 3-2). For both TN and TDN, concentrations at the far end of the MF3 transect were close to the normal range (i.e., slightly above or below).

Figure 3-20 Concentrations of Total Nitrogen in Lac de Gras and Lac du Sauvage According to Distance from the Effluent Discharge, 2020



Note: LDS-4 and LDG-48 results are presented in separate panels, to the left and right of the y-axis, respectively. Station LDS-4 was not sampled during ice-cover season. Shaded bands around fitted prediction lines are 95% confidence intervals (back-transformed to original scale of the variable).

µg-N/L = micrograms nitrogen per litre; NF = near-field; MF = mid-field; FF = far-field; T = top depth; M = middle depth; B = bottom depth; LDG-48 = Lac de Gras outlet; LDS-4 = Lac du Sauvage outlet (the Narrows).

Table 3-2 Gradient Analysis Results for Nutrients, 2020

Variable	Season	Model	Transformation	Gradient	Slope[a]	Breakpoint (km)[b]	*P*-value	r^2 or R^2 [c]
Total Nitrogen	Ice-cover	Model 2	-	MF1	↓	-	**<0.001**	0.71
		Model 2		MF2	↓	-	**0.033**	
		Model 3		MF3 (1st slope)	↓	2.8	**0.019**	0.89
		Model 3		MF3 (2nd slope)	↓		-	
	Open-water[d]	Model 1	Log	MF1	↓	-	**<0.001**	0.67
		Model 1		MF2	↓	-	0.108	
		Model 1		MF3	↓	-	**<0.001**	
Total Dissolved Nitrogen	Ice-cover	Model 1	Log	MF1	↓	-	**0.001**	0.70
		Model 1		MF2	↓	-	0.056	
		Model 1		MF3	↓	-	**<0.001**	
	Open-water	Model 2	Log	MF1	↓	-	**0.037**	0.20
		Model 2		MF2	↑	-	0.809	
		Model 3		MF3 (1st slope)	↓	4.0	0.055	0.75
		Model 3		MF3 (2nd slope)	↑		-	
Total Kjeldahl Nitrogen	Ice-cover	Model 1	-	MF1	↓	-	**0.001**	0.64
		Model 1		MF2	↑	-	**0.009**	
		Model 1		MF3	↓	-	**0.003**	
	Open-water	Model 1	Log	MF1	↓	-	**0.026**	0.35
		Model 1		MF2	↓	-	0.570	
		Model 1		MF3	↓	-	**0.002**	
Dissolved Kjeldahl Nitrogen	Ice-cover	Model 1	Log	MF1	↑	-	0.601	0.31
		Model 1		MF2	↑	-	**0.042**	
		Model 1		MF3	↓	-	**0.019**	
	Open-water[e]	Model 1	Log	MF1	↓	-	**0.047**	0.13
		Model 1		MF2	↑	-	0.583	
		Model 1		MF3	↓	-	0.190	
Nitrate	Ice-cover	Model 2	Log	MF1	↓	-	**<0.001**	0.79
		Model 2		MF2	↓	-	**<0.001**	
		Model 3		MF3 (1st slope)	↓	3.9	**0.027**	0.93
		Model 3		MF3 (2nd slope)	↓		-	
Nitrate + Nitrite	Ice-cover	Model 2	-	MF1	↓	-	**<0.001**	0.77
		Model 2		MF2	↓	-	**0.001**	
		Model 3		MF3 (1st slope)	↓	3.8	**0.034**	0.92
		Model 3		MF3 (2nd slope)	↓		-	

Table 3-2 Gradient Analysis Results for Nutrients, 2020 (continued)

Variable	**Season**	**Model**	**Transformation**	**Gradient**	**Slope(a)**	**Breakpoint (km)(b)**	***P*-value**	**r^2 or R^2 (c)**
Total Ammonia - ALS	Ice-cover	Model 2	Log	MF1	↓		**<0.001**	0.64
		Model 2		MF2	↓		0.828	
		Model 3		MF3 (1st slope)	↓	4.4	**0.009**	0.75
		Model 3		MF3 (2nd slope)	↑		-	
Soluble Reactive Silica	Ice-cover	Model 2	-	MF1	↓	-	**0.004**	0.58
		Model 2		MF2	↓	-	**0.001**	
		Model 3		MF3 (1st slope)	↓	4.0	**<0.001**	0.99
		Model 3		MF3 (2nd slope)	↓		-	
	Open-water	Model 2	-	MF1	↓	-	**<0.001**	0.74
		Model 2		MF2	↓	-	0.186	
		Model 3		MF3 (1st slope)	↓	3.6	**<0.001**	0.98
		Model 3		MF3 (2nd slope)	↓		-	

a) Slope direction was represented by an upward arrow (↑) indicating an increasing trend with distance from the effluent diffusers, or a downward arrow (↓) indicating a decreasing trend with distance from the effluent diffusers.

b) The breakpoint is the location from the effluent discharge where the slopes of the linear regressions along the MF3 transect changed value.

c) For the MF3 broken stick model, r^2 is calculated because there is only one predictor, which is distance; for the other models, R^2 is calculated, because there is more than one predictor, i.e., distance and gradient.

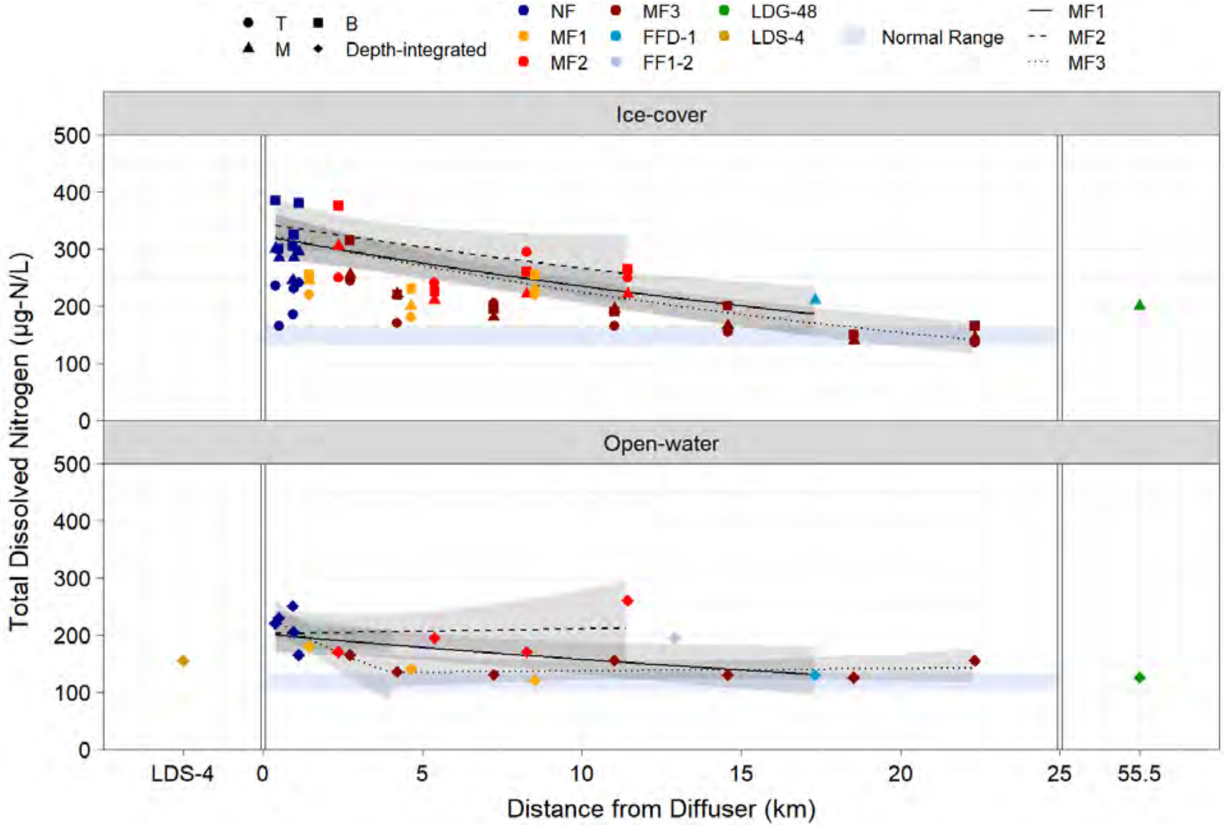
d) Outliers removed: 530 µg-N/L, 475 µg-N/L, and 295 µg-N/L.

e) Outlier removed: 195 µg-N/L.

Note: **Bold** indicates *P*-value significant at <0.05. Gradient analysis was not done for the following variables because of low detection frequency: total phosphorus (ice-cover and open-water), total dissolved phosphorus (ice-cover and open-water), soluble reactive phosphorus (ice-cover and open-water), nitrate (open-water), nitrite (ice-cover and open-water), nitrate + nitrite (open-water), ammonia (open-water).

- = not applicable; MF = mid-field; *P* = probability; r^2 or R^2 = coefficient of determination.

Figure 3-21 **Concentrations of Total Dissolved Nitrogen in Lac de Gras and Lac du Sauvage According to Distance from the Effluent Discharge, 2020**



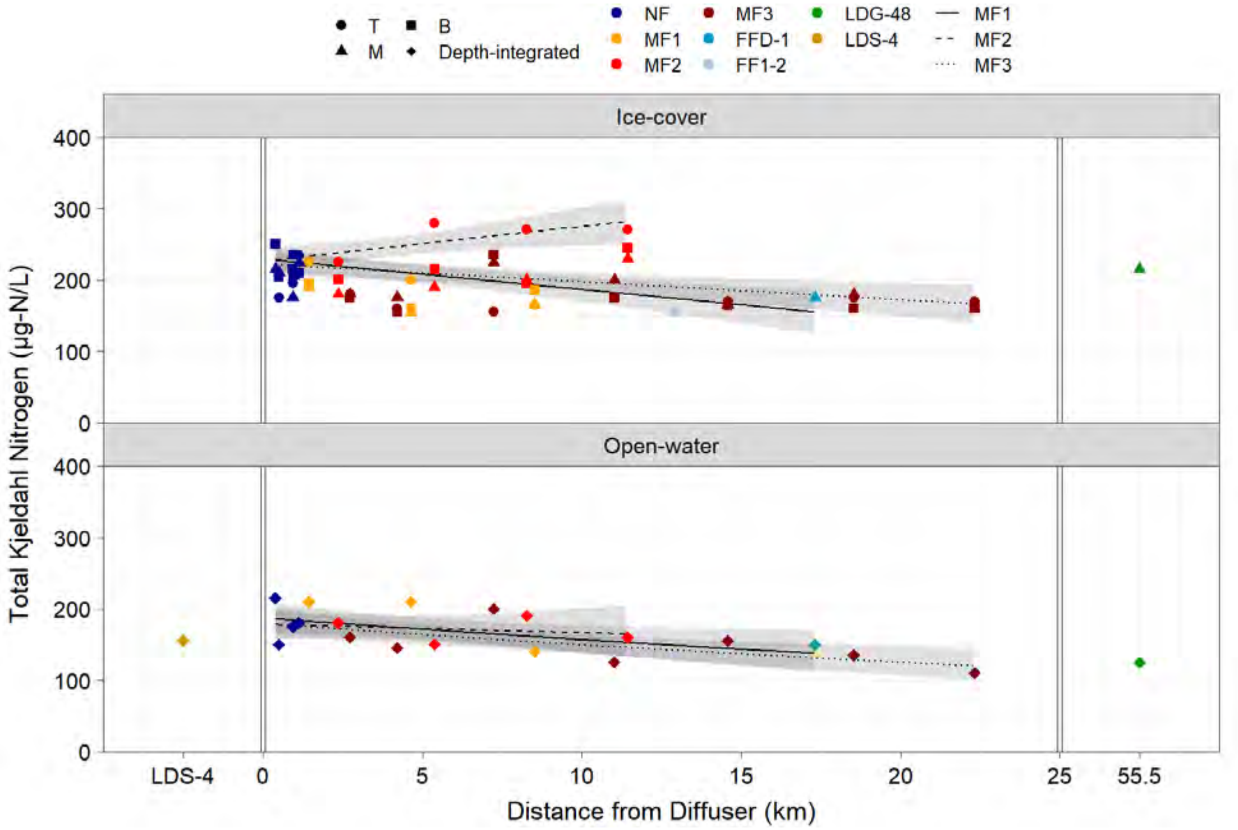
Note: LDS-4 and LDG-48 results are presented in separate panels, to the left and right of the y-axis, respectively. Station LDS-4 was not sampled during ice-cover season. Shaded bands around fitted prediction lines are 95% confidence intervals (back-transformed to original scale of the variable).

µg-N/L = micrograms nitrogen per litre; NF = near-field; MF = mid-field; FF = far-field; T = top depth; M = middle depth; B = bottom depth; LDS-4 = Lac du Sauvage outlet (the Narrows).

Gradients in TKN concentrations were similar to those in TN, except in the MF2 transect during the ice-cover season, where TKN had a significant increasing trend with distance from the diffuser (Table 3-2, Figure 3-22). Significant decreasing trends in concentrations of TKN were observed along the MF1 and MF3 transects during the ice-cover season, and along the MF1 and MF3 transects during the open-water season (Table 3-2, Figure 3-22).

Significant increasing trends in concentrations of DKN were also observed along the MF2 transect during the ice-cover season, while decreasing trends of concentrations were observed along the MF3 transect during the ice-cover season and along the MF1 transect during the open-water season (Table 3-2, Figure 3-23).

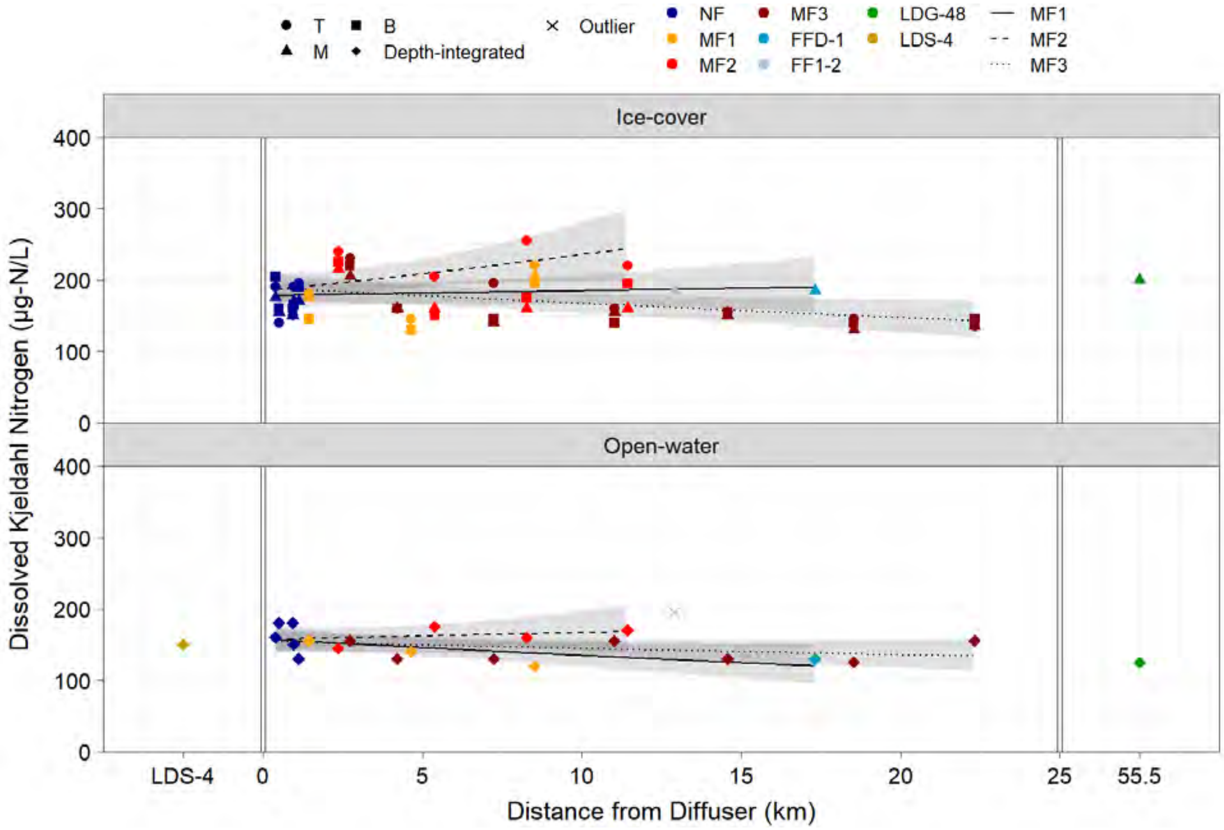
Figure 3-22 Concentrations of Total Kjeldahl Nitrogen in Lac de Gras and Lac du Sauvage According to Distance from the Effluent Discharge, 2020



Note: LDS-4 and LDG-48 results are presented in separate panels, to the left and right of the y-axis, respectively. Station LDS-4 was not sampled during ice-cover season. Shaded bands around fitted prediction lines are 95% confidence intervals (back-transformed to original scale of the variable).

µg-N/L = micrograms nitrogen per litre; NF = near-field; MF = mid-field; FF = far-field; T = top depth; M = middle depth; B = bottom depth; LDG-48 = Lac de Gras outlet; LDS-4 = Lac du Sauvage outlet (the Narrows).

Figure 3-23 Concentrations of Dissolved Kjeldahl Nitrogen in Lac de Gras and Lac du Sauvage According to Distance from the Effluent Discharge, 2020

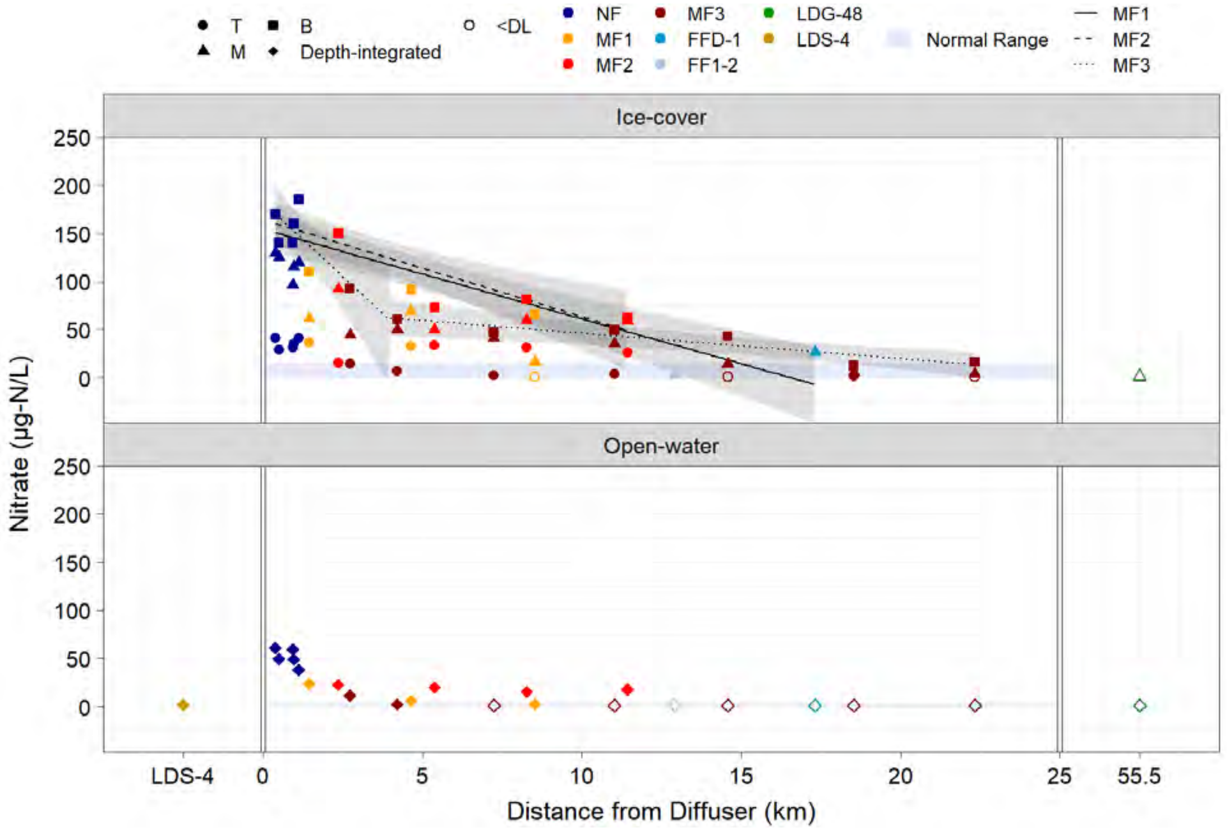


Note: LDS-4 and LDG-48 results are presented in separate panels, to the left and right of the y-axis, respectively. Station LDS-4 was not sampled during ice-cover season. Shaded bands around fitted prediction lines are 95% confidence intervals (back-transformed to original scale of the variable).

µg-N/L = micrograms nitrogen per litre; NF = near-field; MF = mid-field; FF = far-field; T = top depth; M = middle depth; B = bottom depth; LDG-48 = Lac de Gras outlet; LDS-4 = Lac du Sauvage outlet (the Narrows).

Concentrations of nitrate were generally greater than the normal range during the ice-cover season with some exceptions (Figure 3-24). Significant decreasing trends in nitrate concentrations during the ice-cover season were observed along all transects (Table 3-2). The concentration of nitrate at LDG-48 was not detectable, and was lower than concentrations at most other stations in Lac de Gras during the ice-cover season. During the open-water season, nitrate concentrations were not detected frequently enough to allow linear regression analysis. Given that the normal range for nitrate in open-water is set at the DL, any detected concentration would be above the normal range (Figure 3-24). Based on visual evaluation of nitrate concentrations during the open-water season, a shallow decreasing concentration gradient was apparent along each MF transect, to about a 12 km distance from the diffusers.

Figure 3-24 Concentrations of Nitrate in Lac de Gras and Lac du Sauvage According to Distance from the Effluent Discharge, 2020

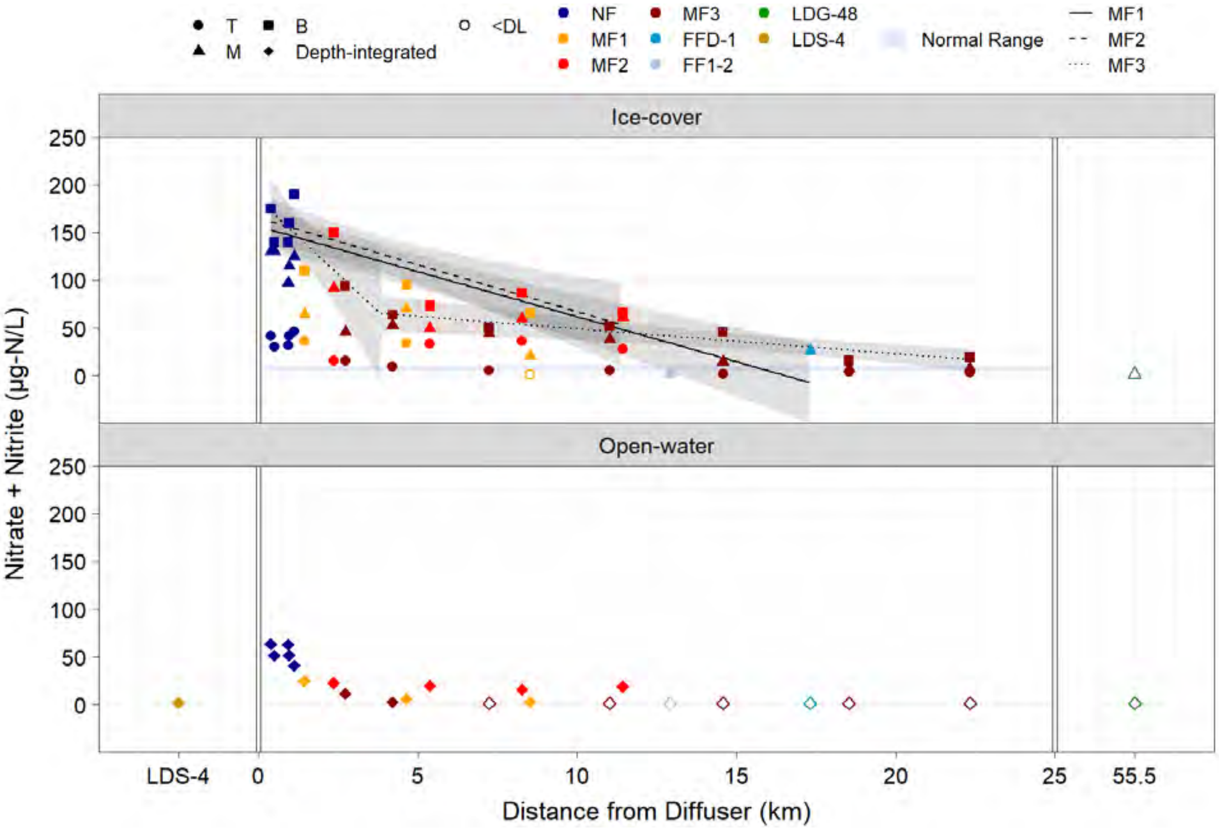


Note: LDS-4 and LDG-48 results are presented in separate panels, to the left and right of the y-axis, respectively. Station LDS-4 was not sampled during ice-cover season. Shaded bands around fitted prediction lines are 95% confidence intervals (back-transformed to original scale of the variable). The open-water data were not statistically analyzed because of the high frequency of non-detects in the dataset.

µg-N/L = micrograms nitrogen per litre; NF = near-field; MF = mid-field; FF = far-field; T = top depth; M = middle depth; B = bottom depth; <DL = less than detection limit; LDG-48 = Lac de Gras outlet; LDS-4 = Lac du Sauvage outlet (the Narrows).

The results for nitrate + nitrite were similar to that for nitrate in terms of the stations with concentrations that exceeded normal range and significant decreasing trends with distance from the diffusers along all transects during the ice-cover season (Table 3-2, Figure 3-25). During the open-water season, nitrate + nitrite concentrations were not detected frequently enough to allow for linear regression analysis. Based on visual evaluation, a shallow decreasing concentration gradient was apparent along each MF transect.

Figure 3-25 Concentrations of Nitrate + Nitrite in Lac de Gras and Lac du Sauvage According to Distance from the Effluent Discharge, 2020

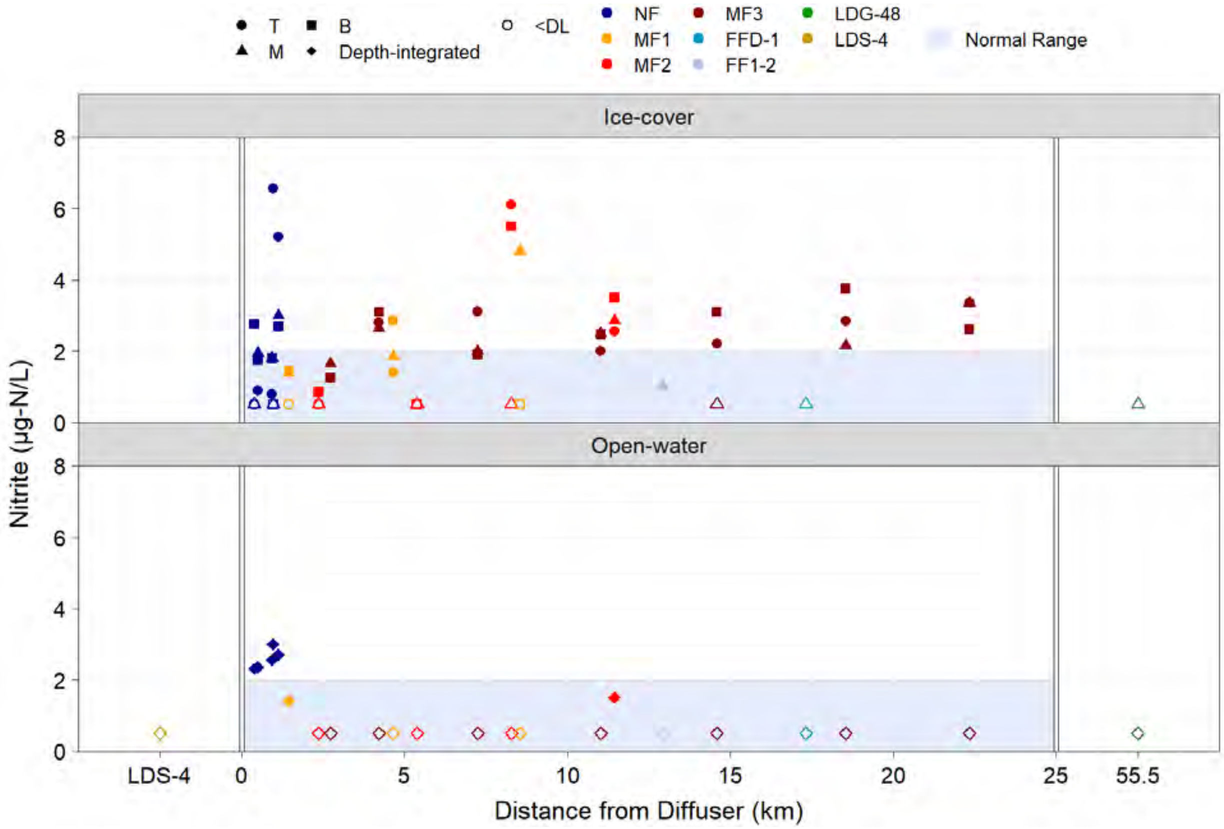


Note: LDS-4 and LDG-48 results are presented in separate panels, to the left and right of the y-axis, respectively. Station LDS-4 was not sampled during ice-cover season. Shaded bands around fitted prediction lines are 95% confidence intervals (back-transformed to original scale of the variable). The open-water data were not statistically analyzed because of the high frequency of non-detects in the dataset.

µg-N/L = micrograms nitrogen per litre; NF = near-field; MF = mid-field; FF = far-field; T = top depth; M = middle depth; B = bottom depth; <DL = less than detection limit; LDG-48 = Lac de Gras outlet; LDS-4 = Lac du Sauvage outlet (the Narrows).

Nitrite concentrations were more frequently detected in the NF area than in the MF areas, with many concentrations in both the NF and MF areas greater than normal range during the ice-cover season (Figure 3-26). However, nitrite concentrations were not detected frequently enough to allow for linear regression analysis in either season. Nitrite was detected less frequently during the open-water season, and detected concentrations were within normal range except for in those measured in the NF area. Based on visual evaluation, obvious decreasing trends were not apparent along the MF transects.

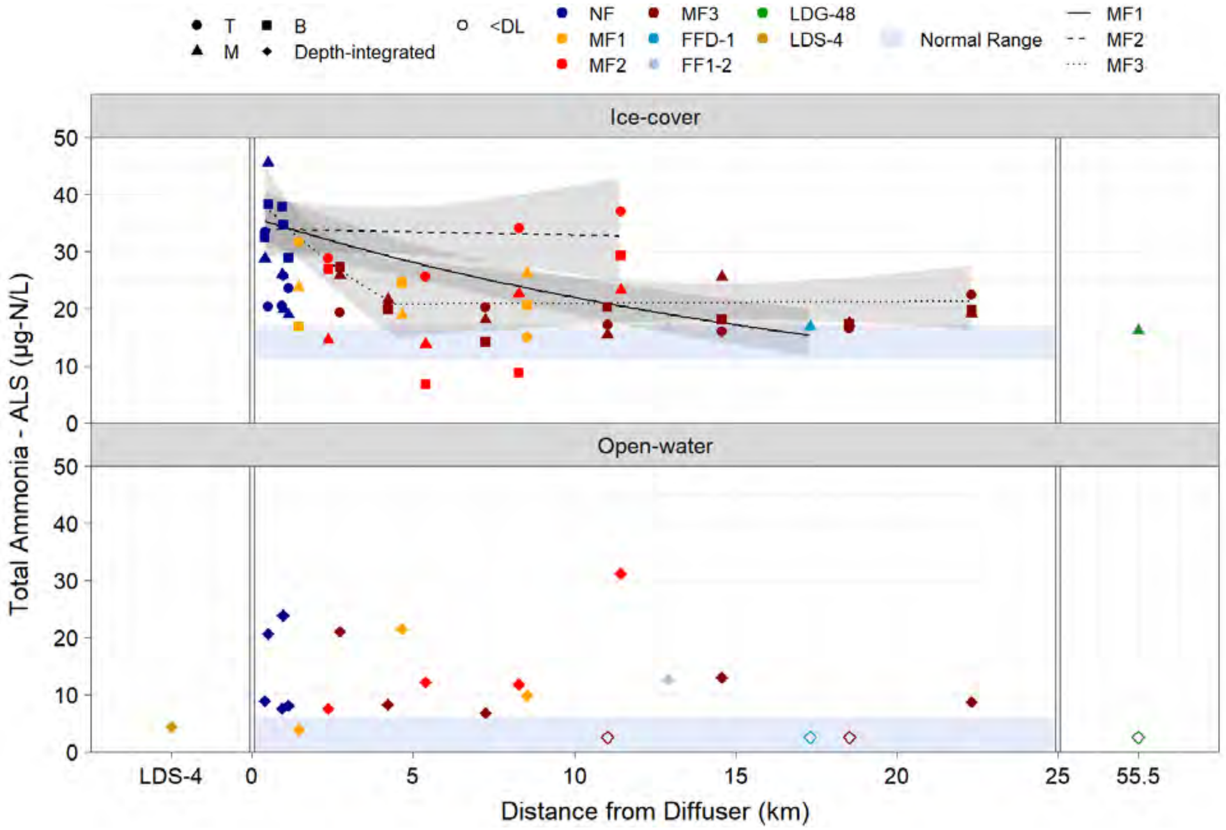
Figure 3-26 Concentrations of Nitrite in Lac de Gras and Lac du Sauvage According to Distance from the Effluent Discharge, 2020



Note: LDS-4 and LDG-48 results are presented in separate panels, to the left and right of the y-axis, respectively. Station LDS-4 was not sampled during ice-cover season. µg-N/L = micrograms nitrogen per litre; NF = near-field; MF = mid-field; FF = far-field; T = top depth; M = middle depth; B = bottom depth; <DL = less than detection limit; LDG-48 = Lac de Gras outlet; LDS-4 = Lac du Sauvage outlet (the Narrows).

Total ammonia concentrations were generally greater than the normal range during both the ice-cover and open-water seasons at most stations (Figure 3-27). A significant decreasing trend with distance from the diffuser was detected along the MF1 transect. A significant decreasing trend was also detected along the MF3 transect, with a reversal in direction beyond the breakpoint of the broken stick regression; the concentration was low again at the lake outlet (Table 3-2). During the open-water season, total ammonia concentrations were not detected frequently enough to allow linear regression analysis (Figure 3-27), and based on visual evaluation, a consistent trend among all three transects was not apparent.

Figure 3-27 Concentrations of Total Ammonia in Lac de Gras and Lac du Sauvage According to Distance from the Effluent Discharge, 2020

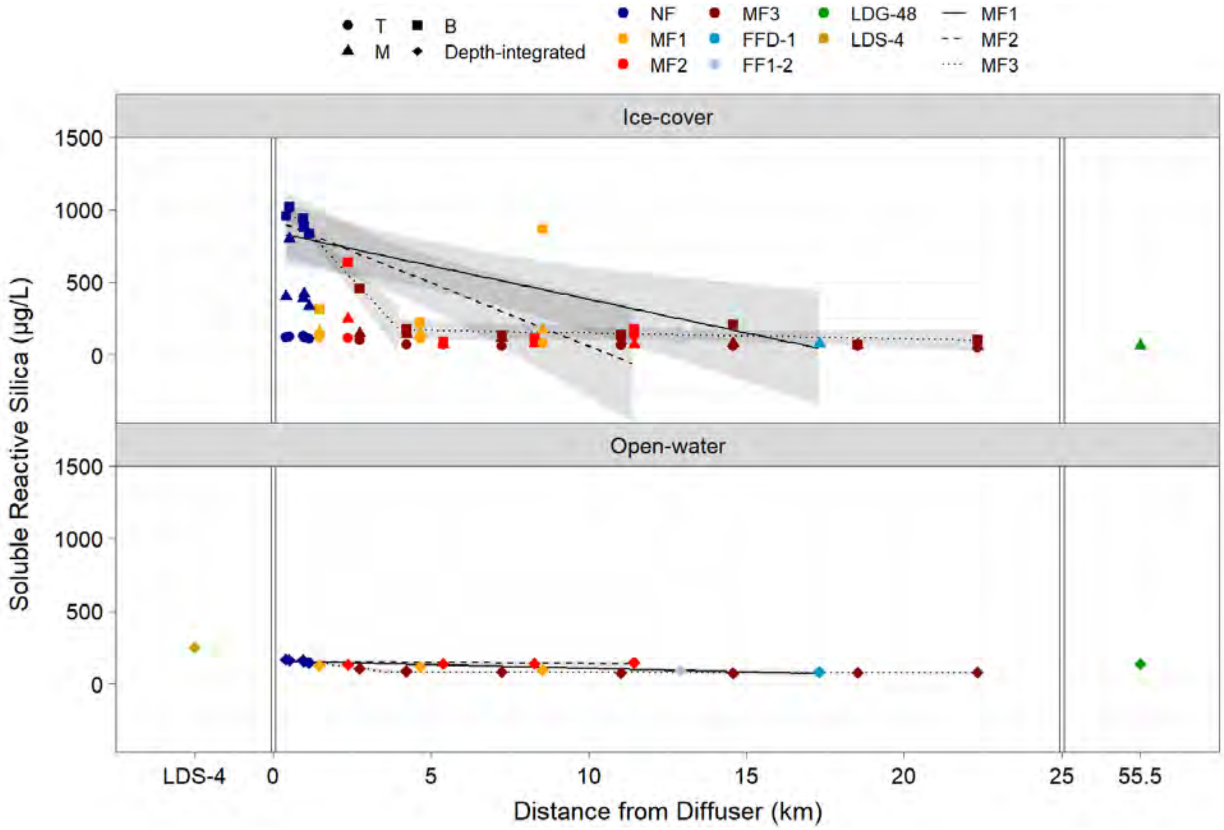


Note: LDS-4 and LDG-48 results are presented in separate panels, to the left and right of the y-axis, respectively. Station LDS-4 was not sampled during ice-cover season. Shaded bands around fitted prediction lines are 95% confidence intervals (back-transformed to original scale of the variable). The open-water data were not statistically analyzed because of the high frequency of non-detects in the dataset.

µg-N/L = micrograms nitrogen per litre; NF = near-field; MF = mid-field; FF = far-field; T = top depth; M = middle depth; B = bottom depth; <DL = detection limit; LDG-48 = Lac de Gras outlet; LDS-4 = Lac du Sauvage outlet (the Narrows).

Significant decreasing trends in concentrations of SRSi were observed along all MF transects during the ice-cover season and along the MF1 and MF3 transects during the open-water season (Table 3-2, Figure 3-28). The concentrations of SRSi were higher during ice-cover compared to the open-water season (Figure 3-12 and Figure 3-28).

Figure 3-28 Concentrations of Soluble Reactive Silica in Lac de Gras and Lac du Sauvage According to Distance from the Effluent Discharge, 2020



Note: LDS-4 and LDG-48 results are presented in separate panels, to the left and right of the y-axis, respectively. Station LDS-4 was not sampled during ice-cover season. Shaded bands around fitted prediction lines are 95% confidence intervals (back-transformed to original scale of the variable). The open-water data were not statistically analyzed because of the high frequency of non-detects in the dataset.

µg/L = micrograms per litre; NF = near-field; MF = mid-field; FF = far-field; T = top depth; M = middle depth; B = bottom depth; LDG-48 = Lac de Gras outlet; LDS-4 = Lac du Sauvage outlet (the Narrows).

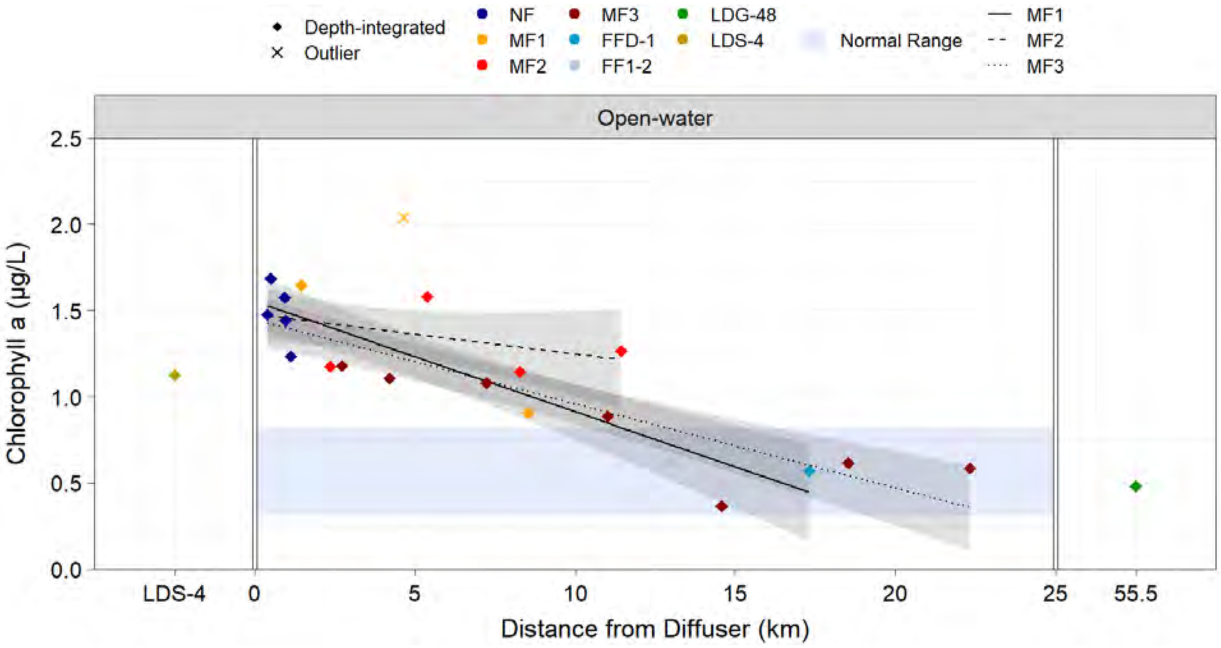
3.2.5.3 Chlorophyll *a*, and Phytoplankton and Zooplankton Biomass

Chlorophyll *a* concentrations exceeded the normal range at all stations that were within approximately 12 km of the diffusers (Figure 3-29). There were significant decreasing trends in chlorophyll *a* concentration with distance from the diffuser along the MF1 and MF3 transects (Table 3-3, Figure 3-29).

Total phytoplankton biomass was above the normal range at the majority of stations in the NF area and one station along the MF1 transect; biomass at all other stations was within the normal range (Figure 3-30). Phytoplankton biomass had significant decreasing trends along the MF1 and MF2 transects (Table 3-3, Figure 3-30).

Zooplankton biomass (as AFDM) was above the normal range in 2020 at almost all stations, except for two stations in the MF3 transect (Figure 3-31). Significant decreasing trends in zooplankton biomass with distance from the diffuser were observed along the MF1 and MF3 transects in 2020 (Table 3-3).

Figure 3-29 Concentrations of Chlorophyll *a* in Lac de Gras and Lac du Sauvage According to Distance from the Effluent Discharge, 2020



Note: LDS-4 and LDG-48 results are presented in separate panels, to the left and right of the y-axis, respectively. Shaded bands around fitted prediction lines are 95% confidence intervals (back-transformed to original scale of the variable).

µg/L = micrograms per litre; NF = near-field; MF = mid-field; FF = far-field; LDG-48 = Lac de Gras outlet; LDS-4 = Lac du Sauvage outlet (the Narrows).

Table 3-3 Gradient Analysis Results for Biological Variables during the Open-Water Season, 2020

Variable	Model	Transformation	Gradient	Slope(a)	Breakpoint (km)(b)	*P*-value	r^2 or R^2(c)
Chlorophyll *a*(d) (µg/L)	Model 1	-	MF1	↓	-	**<0.001**	0.78
	Model 1		MF2	↓	-	0.161	
	Model 1		MF3	↓	-	**<0.001**	
Phytoplankton Biomass(e) (mg/m^3)	Model 2	Log	MF1	↓	-	**0.001**	0.65
	Model 2		MF2	↓	-	**<0.001**	
	Model 3		MF3 (1st slope)	↓	1.5	0.229	0.74
	Model 3		MF3 (2nd slope)	↓		-	
Zooplankton Biomass as AFDM (mg/m^3)	Model 1	Log	MF1	↓	-	**0.006**	0.42
	Model 1		MF2	↓	-	0.971	
	Model 1		MF3	↓	-	**0.003**	

a) Slope direction was represented by an upward arrow (↑) indicating an increasing trend with distance from the effluent diffusers, or a downward arrow (↓) indicating a decreasing trend with distance from the effluent diffusers.

b) The breakpoint is the location from the effluent discharge where the slopes of the linear regressions along the MF3 transect changed value.

c) For the MF3 broken stick model, r^2 is calculated because there is only one predictor, which is distance; for the other models, R^2 is calculated, because there is more than one predictor, i.e., distance and gradient.

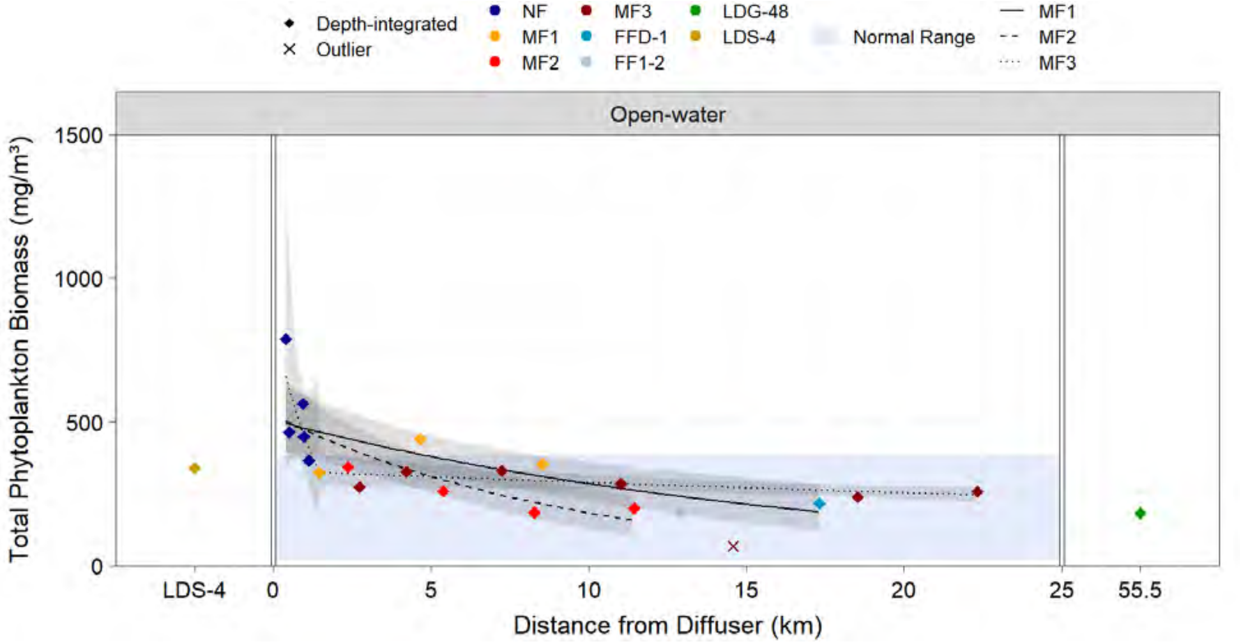
d) Outlier removed: 2.04 µg/L.

e) Outlier removed: 67 mg/m^3.

Note: **Bold** indicates *P*-value significant at <0.05. The *P*-value relevant to the second slope is not reported by the statistical software because it cannot be estimated (Muggeo 2008).

µg/L = micrograms per litre; AFDM = ash-free dry mass; MF = mid-field; - = not applicable; < = less than; r^2 or R^2 = coefficient of determination.

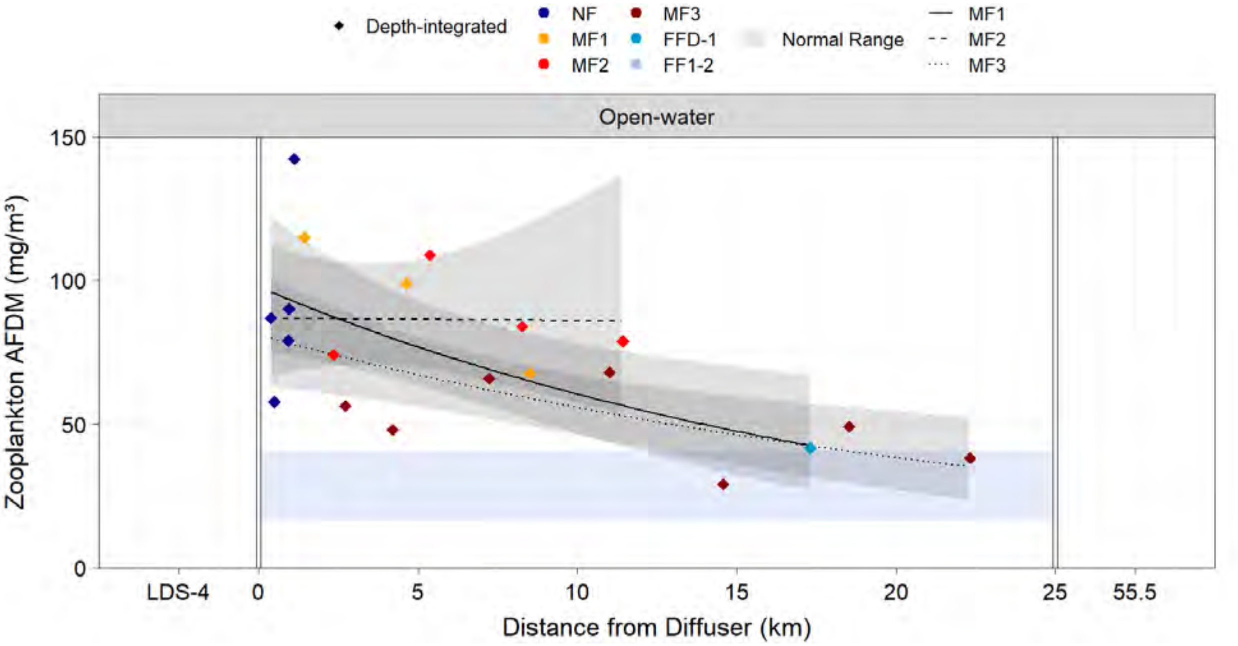
Figure 3-30 Total Phytoplankton Biomass in Lac de Gras and Lac du Sauvage According to Distance from the Effluent Discharge, 2020



Note: LDS-4 and LDG-48 results are presented in separate panels, to the left and right of the y-axis, respectively. Shaded bands around fitted prediction lines are 95% confidence intervals (back-transformed to original scale of the variable).

mg/m^3 = milligrams per cubic metre; NF = near-field; MF = mid-field; FF = far-field; LDG-48 = Lac de Gras outlet; LDS = Lac du Sauvage outlet (the Narrows).

Figure 3-31 Total Zooplankton Biomass in Lac de Gras and Lac du Sauvage According to Distance from the Effluent Discharge, 2020



Note: LDS-4 and LDG-48 results are presented in separate panels, to the left and right of the y-axis, respectively. Shaded bands around fitted prediction lines are 95% confidence intervals (back-transformed to original scale of the variable).

An error by the analytical laboratory resulted in an aliquot being removed for a different analysis from most sample bottles prior analysis of zooplankton biomass. An investigation determined the bias was low (<2% decrease in biomass) and therefore the results were not corrected for this bias.

mg/m^3 = milligrams per cubic metre; NF = near-field; MF = mid-field; FF = far-field; LDG-48 = Lac de Gras outlet; LDS = Lac du Sauvage outlet (the Narrows).

3.2.6 Extent of Effects

As required by Directive 2B from the 25 March 2019 WLWB Decision regarding the *AEMP 2017 Annual* Report (Golder 2018), the spatial extent of effects of eutrophication indicators was estimated for both the ice-cover and open-water seasons, and all three depths (i.e., top, middle, and bottom) for the ice-cover season. Maximum extent of effects for each variable is shown in figures in this section, and seasonal extents of effects are shown in Attachment E.

The spatial extent of effects on TP concentrations has generally been low throughout the AEMP monitoring years, and the lake area affected has remained at or near 0% since 2018 (Figure 3-32, Table 3-4). In 2020, concentrations of TP were below the normal range at all stations in both seasons, and at all depths (Figure 3-33). Therefore, the area of the lake affected was 0% (Table 3-4).

The area of the lake affected for TN was greater than or equal to 48% based on ice-cover bottom depth concentrations (Table 3-4 and Figure 3-34). As TN concentrations were greater than the normal range at the MF3-7 station, and sampling did not occur in the FFA and FFB areas during the 2020 sampling program, the extent of effects could have been greater than the estimated area. However, given that TN concentrations in the middle and top ice-cover samples did not extend through the MF3 transect, it is unlikely that the area affected extended much farther past MF3-7, or to the lake outlet, as reported in previous years of monitoring (Figure E-1).

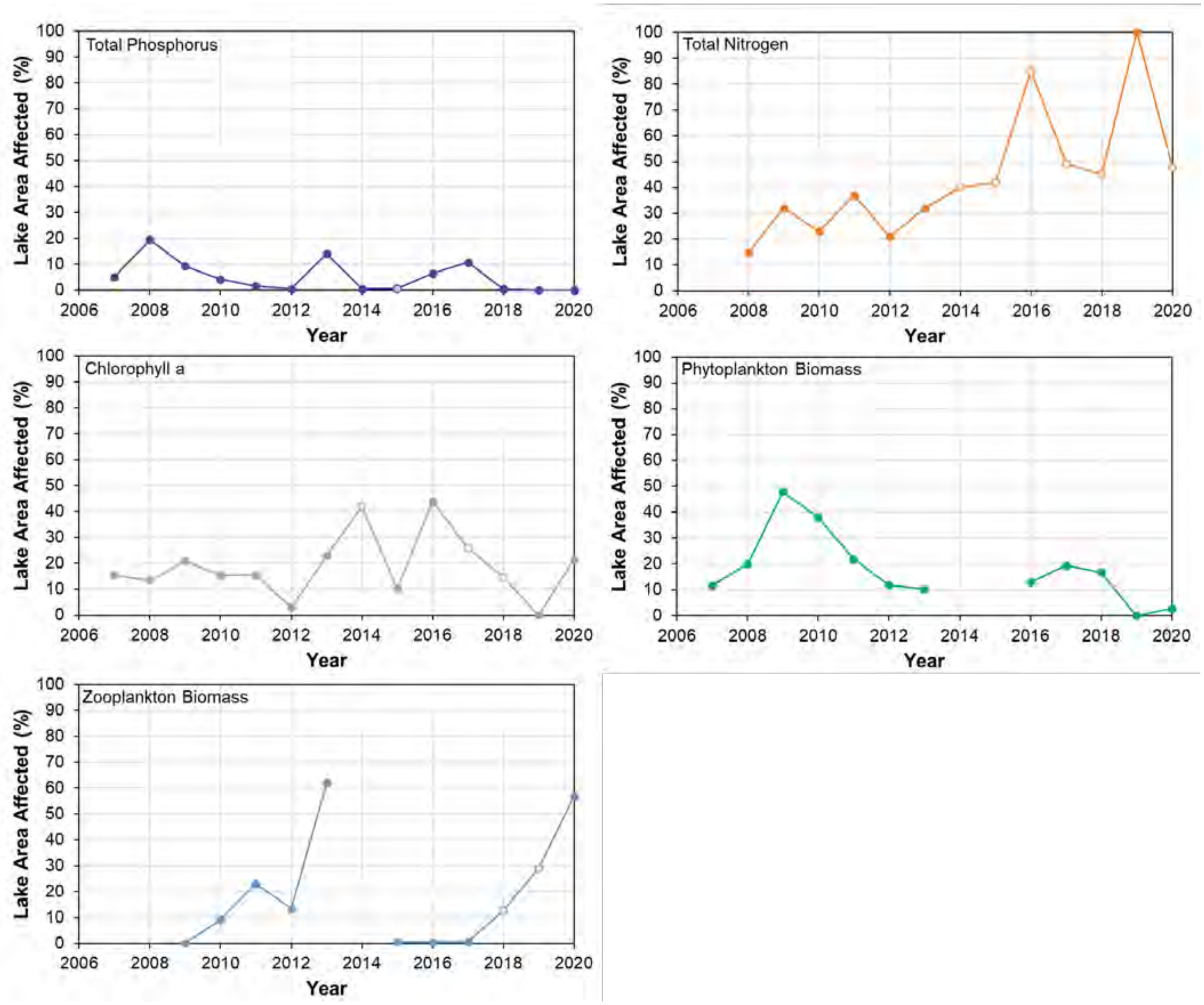
Monitoring at FF1-2 and the new FFD-1 station during the 2020 interim monitoring year improved the ability to estimate spatial extent of effects for TN. As noted in Section 2.3, the reported TN concentration at FFD-1 during the open-water season was much greater than the other nitrogen species, particularly TKN. Therefore, this value was considered likely to be inaccurate. The TKN value was instead used for the extent of effects calculations and remained below the normal range at FFD-1 during the open-water season. The reported value for the concentration of TN at FFD-1 during the ice-cover season was considered acceptable and was included in the extent of effects calculation. The concentration at FFD-1 during ice-cover was greater than the normal range; the extent of effect of TN extended through the MF3 transect, moving north to the FFD-1 station (Figure E-1).

In 2020, effects of chlorophyll *a* were observed in the NF area and along the entire MF2 transect. Concentrations of chlorophyll *a* extended slightly past the MF1-3 and MF3-4 stations along the MF1 and MF3 transects, respectively (Figure 3-35). The extent of lake affected in 2020 was 22%, which was greater than estimated for 2018 and 2019, but comparable to 2017 (Table 3-4).

Total phytoplankton biomass was greater than the normal range in the NF area and extended between stations MF1-3 and MF1-5 (Figure 3-36). The area of the lake affected was 2.8%, which is similar to results observed in 2019 (Figure 3-32; Table 3-4). This smaller extent of effects for total phytoplankton biomass is consistent with the results for TP.

Effects on zooplankton biomass (as AFDM) were observed in the NF area and extended along all three transects (Figure 3-37). The boundary of effects on zooplankton biomass to the northwest (i.e., MF1 transect) extended to FF1-2 and the new FFD-1 station. The boundary of effects to the northeast of the Mine (i.e., MF2 transect) extended throughout the entire transect, reaching the Lac de Sauvage outlet (LDS-4). The boundary to the south of the Mine (i.e., MF3 transect) extended past MF3-6. The area demonstrating effects on zooplankton biomass (as AFDM) represents 326 km^2, or 57% of the lake area (Table 3-4).

Figure 3-32 Eutrophication Indicators Affected Area in Lac de Gras, 2007 to 2020



Note: Open symbols represent years where the percent lake area affected could not be estimated with certainty due to limited sampling in the far-field area. Breaks in connecting lines represent years with no data.

Table 3-4 Spatial Extent of Effects on Concentrations of Total Phosphorus, Total Nitrogen and Chlorophyll *a*, and Phytoplankton and Zooplankton Biomass, 2007 to 2020

Year	Total Phosphorus		Total Nitrogen		Chlorophyll *a*		Phytoplankton Biomass		Zooplankton Biomass (AFDM)	
	Area (km^2)(a)	Lake Area (%)(a,b)	Area (km^2) (a)	Lake Area (%)(a,b)	Area (km^2)	Lake Area (%)(b)	Area (km^2)	Lake Area (%)(b)	Area (km^2)	Lake Area (%)(b)
2007	29	5.1	-	-	89	15.5	67	11.7	-	-
2008	112	19.6	85	14.8	77	13.5	116	20	-	-
2009	54	9.3	180	32	121	21	274	48	0	0
2010	24	4.2	132	23	89	15.5	217	38	52	9.1
2011	9.2	1.6	213	37	89	15.6	125	22	129	23
2012	3.6	0.6	118	21	17.0	3.0	67	11.8	77	13.4
2013	81	14.1	183	32	129	23	59	10.4	355	62
2014	3.5	0.6	≥230(c)	≥40(c)	≥243(c)	≥42(c)	-(d)	-(d)	-	-
2015	<3.5(f)	<0.6(f)	≥243(c)	≥42(c)	59	10.3	-(d)	-(d)	<3.5(f)	<0.6(f)
2016	37	6.5	≥485(c)	≥85(c)	250	44	75	13.0	2.9	0.5
2017	0 (OW)	0 (OW)	≥257 (OW)(c)	≥49 (OW)(c)	≥150(c)	≥26(c)	111	19.4	<3.5(f)	<0.6(f)
	62 (IC)	10.8 (IC)	≥240 (IC)(c)	≥42 (IC)(c)						
2018	0 (OW)	0 (OW)	229 (OW)	40 (OW)	≥84(c)	≥14.7(c)	96	16.8	≥74(c)	≥12.8(c)
	2.6 (IC)	0.5 (IC)	≥257(c)	≥45(c)						
2019	0(g)	0(g)	573 (OW)	100 (OW)	0.5	0.1	0	0	≥168(c)	≥29(c)
			484 (IC)	85 (IC)						
2020	0(g)	0(g)	231 (OW)	40 (OW)	123	22	16.2	2.8	326	57
			≥276 (IC)(c)	≥48 (IC)(c)						

a) For years 2007 to 2016, lake area reported for total phosphorus and total nitrogen is the greater of the area affected during the ice-cover and open-water seasons. For years 2017 to 2020, lake area affected by nutrient concentrations greater than normal range was calculated for both the open-water and ice-cover seasons, and for all three depths (top, middle, bottom) for the ice-cover season. The results for the ice-cover season are for the depth with the greatest area affected.

b) The lake area affected represents the percentage (%) of lake area experiencing levels greater than the normal range, and was calculated relative to the total surface area of Lac de Gras (573 km^2).

c) Due to an uncertain effect boundary at the end of the MF1 and/or MF3 transect, the extent of effects could have been greater than the area presented.

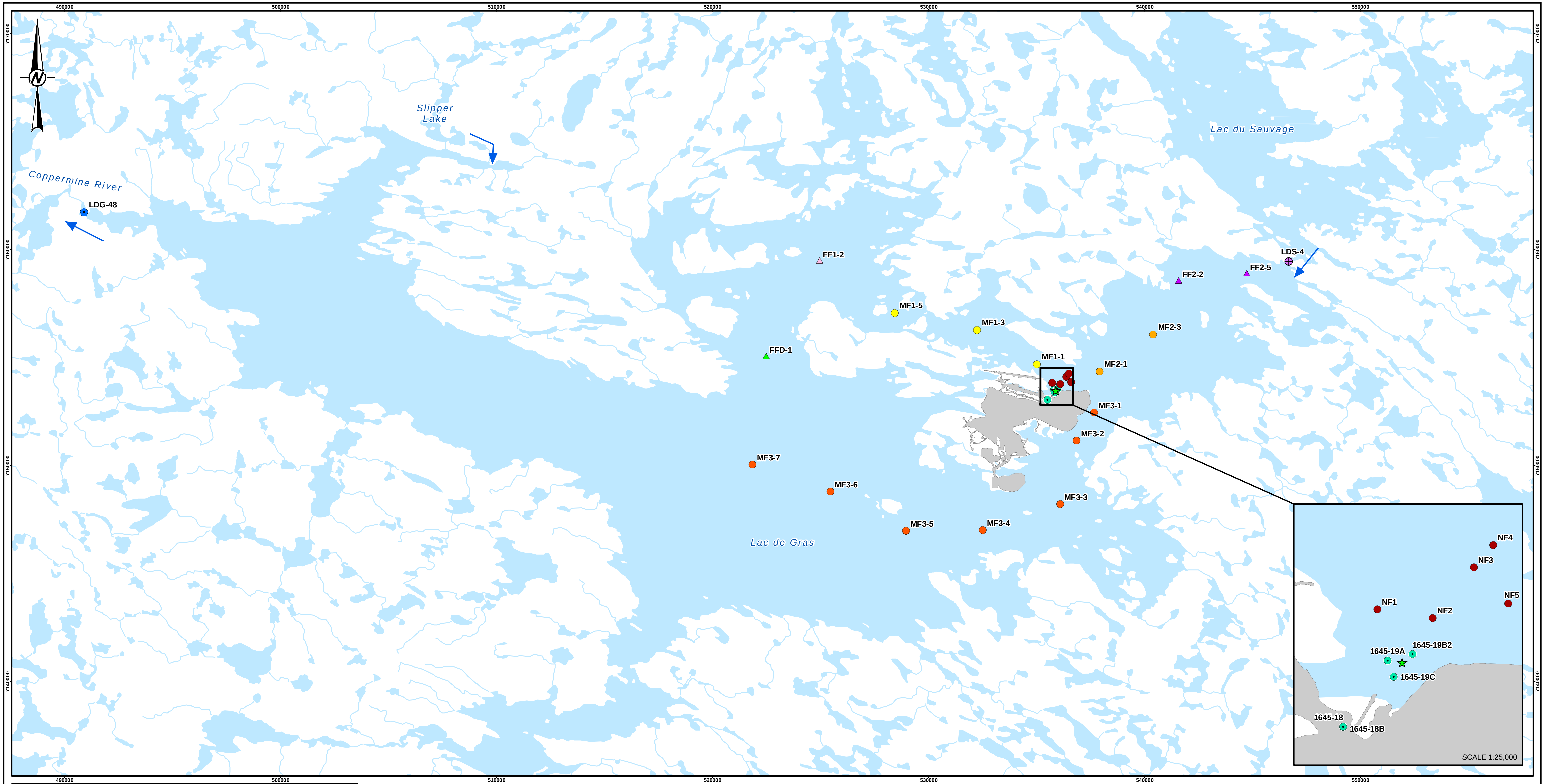
d) Only the NF area was sampled in 2014 and 2015; therefore, extent of effects was not calculated.

f) The mean of the NF area stations was within the normal range. Since only one or two NF stations exceeded the normal range, the affected area was assumed to be less than the total area of the NF area (i.e., 0.6% of lake area).

g) There was no difference in area affected among seasons or depths.

< = less than; ≥ = greater than or equal to; - = no data are available; NF = near-field; MF = mid-field; FF = far-field; AFDM = ash-free dry mass.

Note: To enhance readability, numbers greater than 20 km^2 or 20% in this table were rounded to whole numbers.



LEGEND

★ DIFFUSERS

⊙ SURVEILLANCE NETWORK PROGRAM

STATION LOCATIONS

△ FAR-FIELD 1

▲ FAR-FIELD 2

▲ FAR-FIELD D

⬟ LAC DE GRAS OUTLET

⊕ LAC DU SAUVAGE OUTLET

● MID-FIELD 1

● MID-FIELD 2

● MID-FIELD 3

● NEAR-FIELD

→ FLOW DIRECTION

— WATERCOURSE

▨ AFFECTED AREA[1]

▨ DIAVIK FOOTPRINT

▨ WATERBODY

0 5 10

1:175,000 KILOMETRES

NOTE(S)

1. NO AFFECTED AREA. ALL STATIONS HAD PHOSPHORUS RESULTS THAT WERE LESS THAN THE UPPER BOUND OF THE NORMAL RANGE.

REFERENCE(S)

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PROJECTION: UTM ZONE 12 DATUM: NAD 83

CLIENT

RioTinto

PROJECT

DIAVIK DIAMOND MINES (2012) INC.

CONSULTANT

GOLDER

YYYY-MM-DD	2021-03-22
DESIGNED	MC
PREPARED	LMS
REVIEWED	MC
APPROVED	RLS

TITLE

TOTAL PHOSPHORUS AFFECTED AREA IN LAC DE GRAS, 2020

PROJECT NO.	PHASE	REV.	FIGURE
20136424	10000	0	3-33

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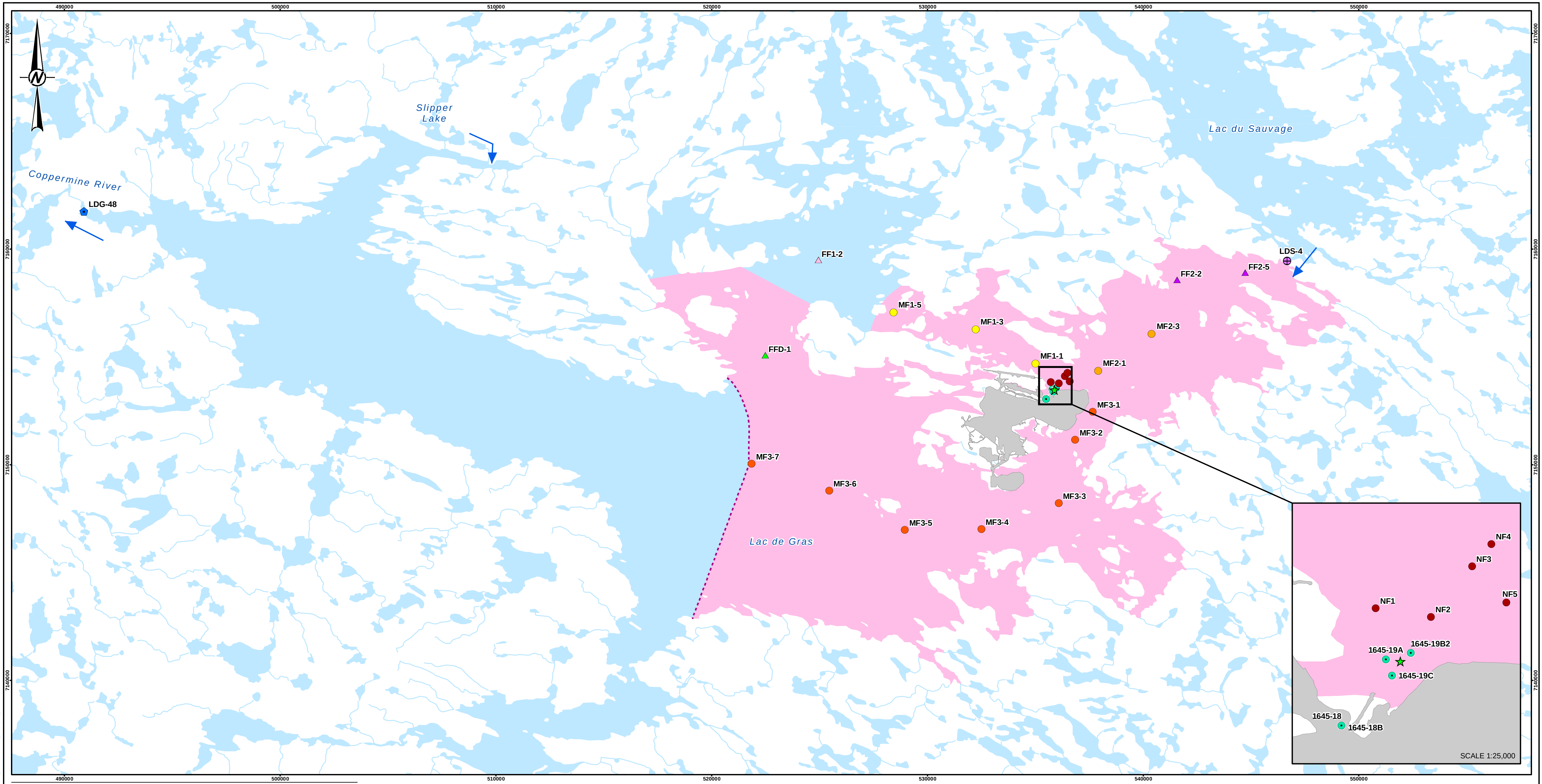

LEGEND

- ★ DIFFUSERS
- ⊙ SURVEILLANCE NETWORK PROGRAM

STATION LOCATIONS

- △ FAR-FIELD 1
- ▲ FAR-FIELD 2
- ▲ FAR-FIELD D
- ⬟ LAC DE GRAS OUTLET
- ⊕ LAC DU SAUVAGE OUTLET
- ● MID-FIELD 1
- ● MID-FIELD 2
- ● MID-FIELD 3
- ● NEAR-FIELD
- → FLOW DIRECTION
- ┅ UNCERTAIN EFFECT BOUNDARY
- ─ WATERCOURSE
- ▨ AFFECTED AREA[1]
- ▨ DIAVIK FOOTPRINT
- ▨ WATERBODY

0 5 10
1:175,000 KILOMETRES

NOTE(S)
1. TOTAL AREA OF THE LAKE AFFECTED IS BASED ON LARGEST EXTENT OF EFFECT ACROSS SAMPLED SEASONS AND DEPTHS.

REFERENCE(S)
HYDROGRAPHY DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
PROJECTION: UTM ZONE 12 DATUM: NAD 83

CLIENT
RioTinto

PROJECT
DIAVIK DIAMOND MINES (2012) INC.

CONSULTANT
GOLDER

YYYY-MM-DD	2021-03-22
DESIGNED	MC
PREPARED	LMS
REVIEWED	MC
APPROVED	RLS

TITLE
TOTAL NITROGEN AFFECTED AREA IN LAC DE GRAS, 2020

PROJECT NO.	PHASE	REV.	FIGURE
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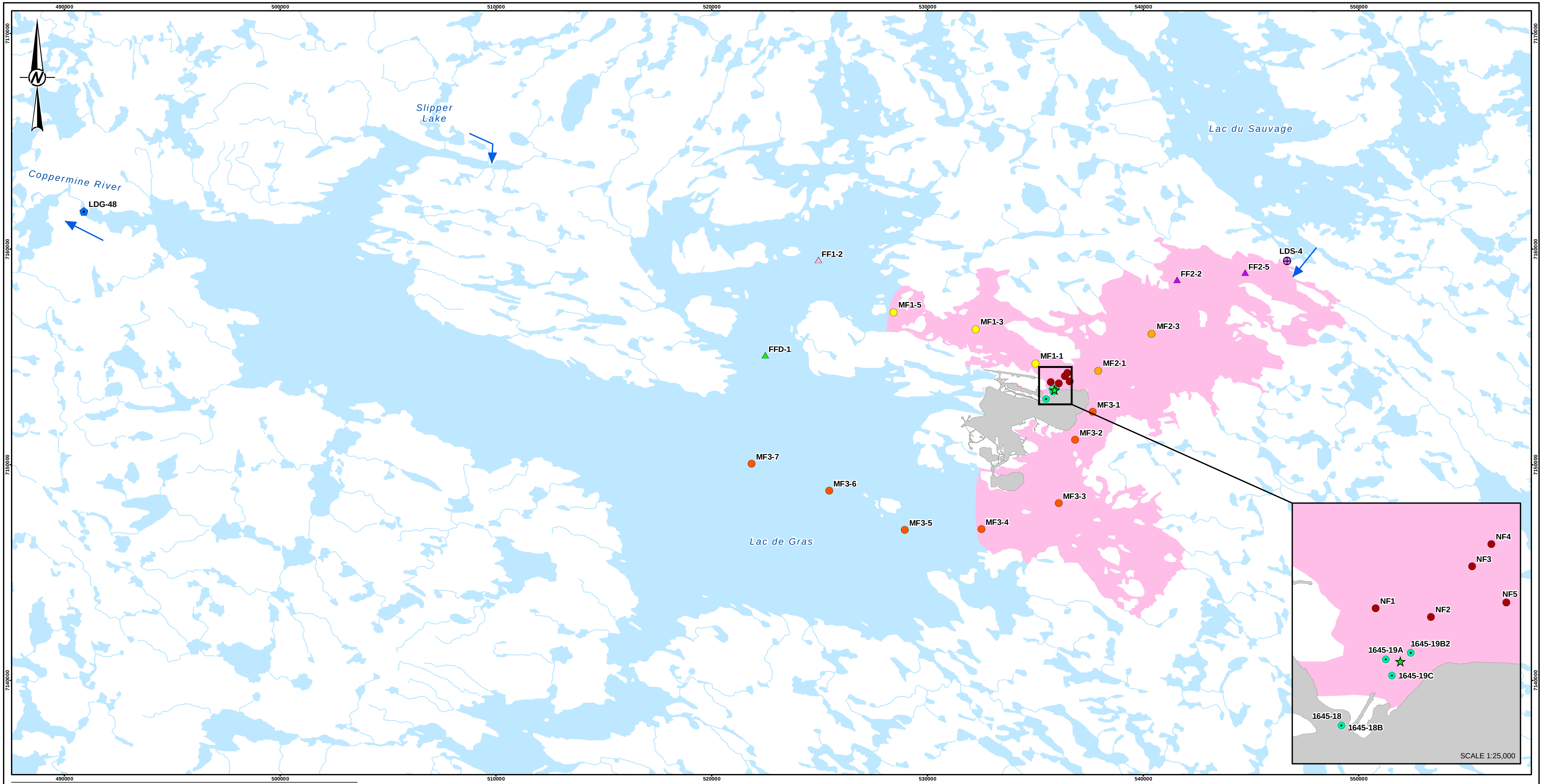

LEGEND

- ★ DIFFUSERS
- ⊙ SURVEILLANCE NETWORK PROGRAM

STATION LOCATIONS

- △ FAR-FIELD 1
- ▲ FAR-FIELD 2
- ▲ FAR-FIELD D
- ⬟ LAC DE GRAS OUTLET
- ⊕ LAC DU SAUVAGE OUTLET
- ● MID-FIELD 1
- ● MID-FIELD 2
- ● MID-FIELD 3
- ● NEAR-FIELD
- → FLOW DIRECTION
- — WATERCOURSE
- ▇ AFFECTED AREA[1]
- ▇ DIAVIK FOOTPRINT
- ▇ WATERBODY

0 5 10

1:175,000 KILOMETRES

NOTE(S)

1. TOTAL AREA OF THE LAKE AFFECTED IS BASED ON OPEN-WATER DATA.

REFERENCE(S)

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PROJECTION: UTM ZONE 12 DATUM: NAD 83

CLIENT

RioTinto

PROJECT

DIAVIK DIAMOND MINES (2012) INC.

CONSULTANT

GOLDER

YYYY-MM-DD	2021-03-22
DESIGNED	MC
PREPARED	LMS
REVIEWED	MC
APPROVED	RLS

TITLE

CHLOROPHYLL A AFFECTED AREA IN LAC DE GRAS, 2020

PROJECT NO.	PHASE	REV.	FIGURE
20136424	10000	0	3-35

PATH: I:\CLIENTS\DIAVIK\20136424\Mapping\Products\Fish\AEMP_2020\Fig3-35_2020_AEMP_AffectedAreas_ChlorophyllA_Rev0.mxd PRINTED ON: 2021-03-22 AT: 9:46:28 AM

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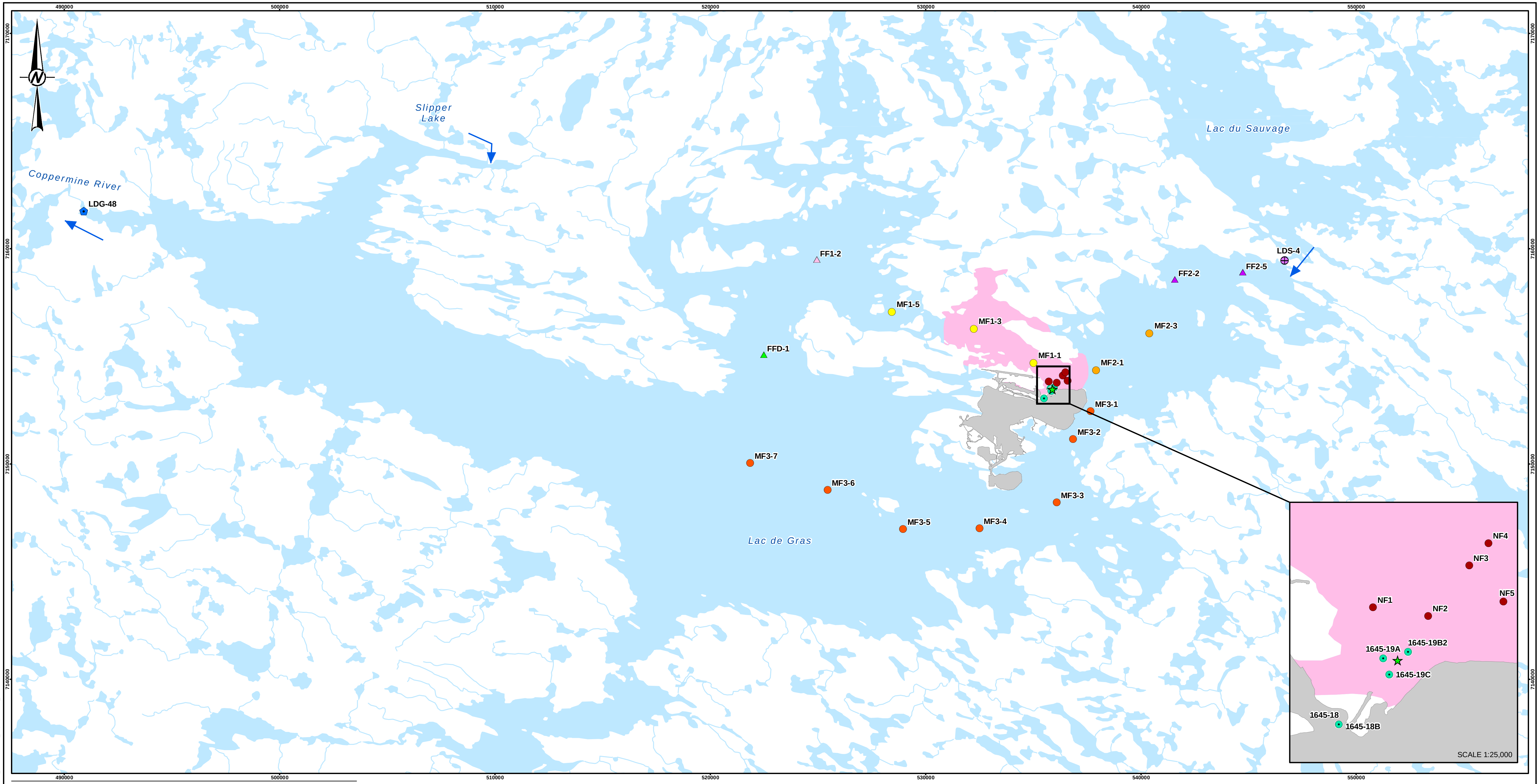

LEGEND

★	DIFFUSERS
⊙	SURVEILLANCE NETWORK PROGRAM

STATION LOCATIONS

△	FAR-FIELD 1
▲	FAR-FIELD 2
▲	FAR-FIELD D
⬟	LAC DE GRAS OUTLET
⊕	LAC DU SAUVAGE OUTLET
●	MID-FIELD 1
●	MID-FIELD 2
●	MID-FIELD 3
●	NEAR-FIELD

→	FLOW DIRECTION
—	WATERCOURSE
▨	AFFECTED AREA[1]
▨	DIAVIK FOOTPRINT
▨	WATERBODY

0 5 10

1:175,000 KILOMETRES

NOTE(S)

1. TOTAL AREA OF THE LAKE AFFECTED IS BASED ON OPEN-WATER DATA.

REFERENCE(S)

HYDROGRAPHY DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
PROJECTION: UTM ZONE 12 DATUM: NAD 83

CLIENT
RioTinto

PROJECT
DIAVIK DIAMOND MINES (2012) INC.

CONSULTANT
GOLDER

YYYY-MM-DD	2021-03-22
DESIGNED	MC
PREPARED	LMS
REVIEWED	MC
APPROVED	RLS

TITLE

TOTAL PHYTOPLANKTON BIOMASS AFFECTED AREA IN LAC DE GRAS, 2020

PROJECT NO.	PHASE	REV.	FIGURE
20136424	10000	0	3-36

PATH: I:\CLIENTS\DIAVIK\20136424\Mapping\Products\Fish\AEMP_2020\Fig3-36_2020_AEMP_AffectedAreas_Phytoplankton_Rev0.mxd PRINTED ON: 2021-03-22 AT: 9:48:21 AM

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25mm

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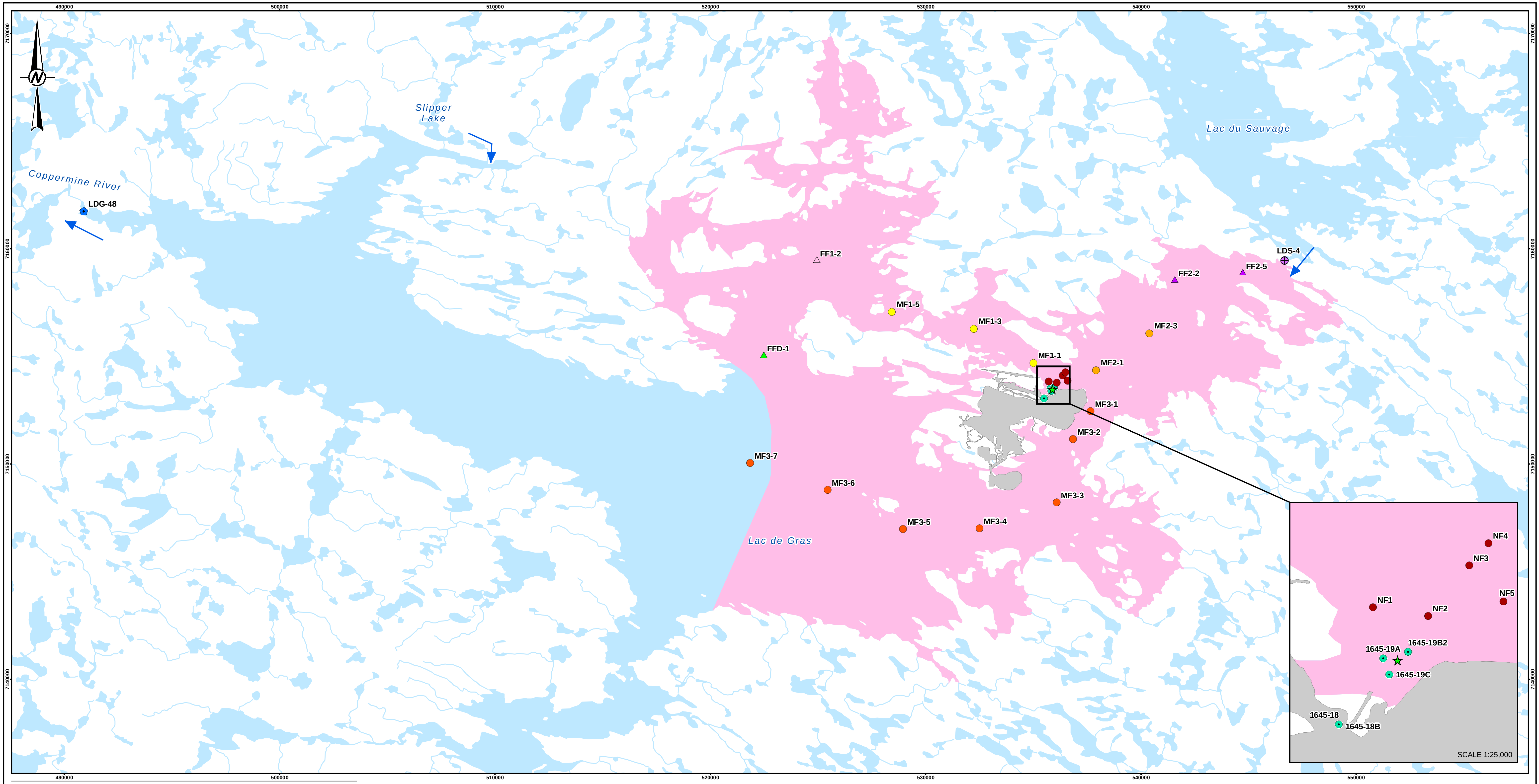

LEGEND

★ DIFFUSERS
⊙ SURVEILLANCE NETWORK PROGRAM

STATION LOCATIONS

△ FAR-FIELD 1
▲ FAR-FIELD 2
▲ FAR-FIELD D
⬟ LAC DE GRAS OUTLET
⊕ LAC DU SAUVAGE OUTLET
● MID-FIELD 1
● MID-FIELD 2
● MID-FIELD 3
● NEAR-FIELD

→ FLOW DIRECTION
— WATERCOURSE
▨ AFFECTED AREA[1]
▨ DIAVIK FOOTPRINT
▨ WATERBODY

0 5 10
1:175,000 KILOMETRES

NOTE(S)

1. TOTAL AREA OF THE LAKE AFFECTED IS BASED ON OPEN-WATER DATA.

REFERENCE(S)

HYDROGRAPHY DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
PROJECTION: UTM ZONE 12 DATUM: NAD 83

CLIENT
RioTinto

CONSULTANT
GOLDER

YYYY-MM-DD	2021-03-22
DESIGNED	MC
PREPARED	LMS
REVIEWED	MC
APPROVED	RLS

PROJECT
DIAVIK DIAMOND MINES (2012) INC.

TITLE
TOTAL ZOOPLANKTON BIOMASS (AS AFDM) AFFECTED AREA IN LAC DE GRAS, 2020

PROJECT NO.	PHASE	REV.	FIGURE
20136424	10000	0	3-37

PATH: I:\CLIENTS\DIAVIK\20136424\Mapping\Products\Fish\AEMP_2020\Fig3-37_2020_AEMP_AffectedAreas_Zooplankton_Rev0.mxd PRINTED ON: 2021-03-22 AT: 9:49:10 AM

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B
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3.2.7 Role of Nitrogen in Spatial Extent of Chlorophyll *a*

Pearson correlation coefficients in 2020 indicated no relationship between TN and chlorophyll *a* (r = 0.099, P = 0.662, n = 22), a weak relationship between TP and chlorophyll *a* (r = 0.424, P = 0.049, n = 22), and moderate, significant correlations between TDS and chlorophyll *a* (r = 0.637, P = 0.001, n = 22) and between SRSi and chlorophyll *a* (r = 0.676, P = 0.001, n = 22). These results are consistent with nitrogen not being the limiting nutrient in Lac de Gras, and also imply a potential Mine-related enrichment effect related to an increase in micronutrients associated with TDS, in addition to TP.

These results are also consistent with the implications of year-to-year variation in effects on nutrient concentrations and productivity indicators illustrated in Figure 3-32. Although a notable increase in the affected area by TN has occurred between 2007 and 2020, similar trends are not apparent in affected areas for indicators of primary productivity. Combined with the results of the correlations described above, monitoring results indicate at most a limited influence of nitrogen loading from the Mine effluent on the spatial extent of effects on primary producers in Lac de Gras.

3.2.8 Effects of Dust Deposition

Phosphorus load to Lac de Gras from dustfall was estimated using snow water chemistry data collected as part of the *2020 Dust Deposition Report* (Appendix I), with consideration of background and anthropogenic TP deposition rates (Attachment F). The methods for calculating TP loads in dust are provided in Attachment F and are the same as those used in the *AEMP 2019 Annual Report* (Golder 2020c) and the *2017 to 2019 Aquatic Effects Re-evaluation Report* (Golder 2020b).

It was assumed that all atmospheric deposition of TP (i.e., background and anthropogenic) that fell within the Lac de Gras watershed either fell directly on Lac de Gras or were delivered to Lac de Gras with no terrestrial attenuation. The lack of terrestrial attenuation is a conservative assumption and is expected to result in an overestimation of the TP load from dustfall to Lac de Gras.

It should be noted that the dust sampling program was not designed to be as precise as the AEMP effluent assessment for measuring TP loading to Lac de Gras. As stated in Section 3.1, the total TP load from Mine effluent based on TP concentrations in effluent discharge was 0.29 tonnes (t) in 2020. This load estimate is associated with a high degree of confidence because it is based on direct measurements of TP concentrations in effluent, and effluent volume. The estimate of the TP load from dust is considered to have low precision, with an order of magnitude variance. Therefore, low confidence should be placed in the estimate of TP load from dust and it should not be directly compared to the TP load from effluent.

In 2020, the rate of dust deposition was greatest within the Mine footprint, declined exponentially with distance, and was indistinguishable from background at approximately 5.0 km from the Mine centroid, which is comparable to the dust ZOI (i.e., 4.8 km) estimated in the *2017 to 2019 Aquatic Effects Re-evaluation Report* (Golder 2020b). Dustfall within the Mine footprint was assumed to be captured within the Mine water management system and thus incorporated within the estimate of TP load in effluent. Therefore, only dustfall to surfaces outside the Mine footprint was included in the estimate of the atmospheric TP load to Lac de Gras. The estimated TP load includes both particulate-bound and potentially bioavailable phosphorus.

The anthropogenic TP loads to Lac de Gras and the watershed (excluding the Mine and lake) in 2020 were 0.69 and 0.35 t, respectively, for a total (including Mine effluent) of 1.3 t in 2020. The anthropogenic TP loads to Lac de Gras (direct and indirect) were consistent with those of 2017 to 2019 (Golder 2020b). Thus, the contribution of anthropogenic sources to the total TP loads to Lac de Gras was 4.2% due to dust and 1.2% due to effluent for a total of 5.4%; the remainder was contributed from natural TP loads, which was comparable to the total anthropogenic contribution of 5.7% estimated for 2017 to 2019 (Golder 2020b).

Although the magnitude of the estimated TP load from dust suggests that dust is a greater contributor to phosphorus-related effects in Lac de Gras than effluent, several lines of evidence indicate that this is not the case:

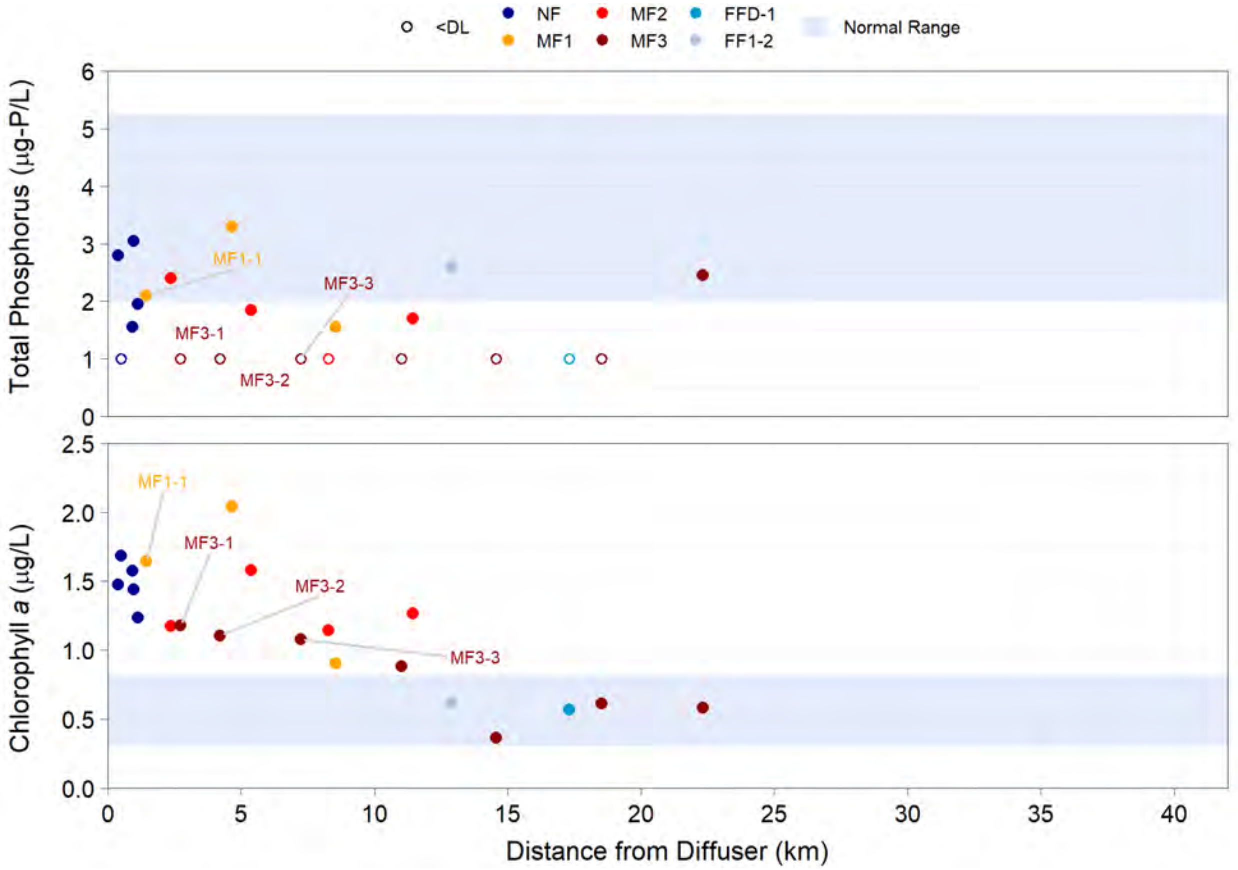
- As stated above, the estimates of TP loads from dust were subject to uncertainty, in part because the loading estimates related to dust did not take into account retention of deposited phosphorus on land.
- A large proportion of phosphorus from dust deposition that reached the lake may not be bioavailable because it would be mostly in particulate form. As discussed in the Dust SES, the potential for mobilization of phosphorus from Mine-related dustfall is low. It is likely that the mineralogical source of phosphorus in dustfall is the phosphate mineral apatite, which has low solubility under the pH and redox conditions in lake water and would not dissolve. Dust-associated phosphorus would settle to the sediment instead of dissolving and becoming available for algae to uptake. Therefore, dust-associated phosphorus is unlikely to contribute dissolved phosphorus in amounts that would result in a measurable contribution to the nutrient enrichment observed in the lake.
- Water quality results indicate that effluent was the primary driver of nutrient enrichment in Lac de Gras. Concentrations of TP in Lac de Gras during the open-water season, measured as part of the 2020 AEMP, were below the normal range at all stations in the ZOI from dust deposition (i.e., NF1 to NF5, MF1-1, MF3 1, MF3-2, MF3-3) (Figure 3-38). Chlorophyll *a* concentrations were greater than the upper bound of the normal range of 0.82 µg/L at all stations in the NF area, along the MF1 and MF2 transects, and up to and including station MF3-4 along the MF3 transect (Figure 3-38). Concentrations followed an overall decreasing trend in concentrations with distance from the diffuser along the MF1 and MF3 transects. This trend is consistent with an effluent-related, rather than a dust-related effect. No significant trend was observed in chlorophyll *a* concentrations along the MF2 transect (Section 3.2.5.3). This is likely due to the input of water entering Lac de Gras from Lac du Sauvage, since station LDS-4 had a TP concentration in the range of the NF stations (Figure 3-17) and a chlorophyll *a* concentration that was above the normal range and similar to those at station FF2-5 (i.e., 1.13 µg/L at LDS-4 and 1.27 µg/L at FF2-5; Figure 3-29).
- In 2020, predominant wind directions at the Mine site were from the east, southeast, and northwest. However, the results of the 2020 *Dust Deposition Report* (Appendix I) show that proximity to Mine activity is a stronger indicator of dust deposition than wind direction. Figure 3-39 shows the relative concentrations of total phosphorus and chlorophyll *a* in relation to the Mine footprint. On these plots, elevated concentrations were observed closest to the diffuser in the NF area, and were not observed to the east and southeast, as would be expected if dust was as prominent a contributor as effluent. Although elevated TP concentrations occurred at some stations, these stations are located at distance from the Mine footprint (e.g., MF1-3, FF1-2, MF3-7, LDS-4). The highest TP concentration was measured at MF1-3, which also had the highest chlorophyll *a* concentration. This station is located north-northwest of the Mine site, outside of the dust ZOI, and is not expected to have a high dust deposition rate based on the results of the 2020 Dust Deposition Report. Elevated chlorophyll *a*

concentrations were observed along the MF2 transect, and are likely influenced by nutrient input from Lac du Sauvage.

- The lack of obvious dust-related effects on TP and chlorophyll *a* in the 2020 AEMP are supported by the Dust SES that was conducted in 2019. TP and chlorophyll *a* sampling was completed at four additional stations in 2019 as part of the Dust SES to evaluate the influence of dust deposition on water quality in Lac de Gras. These stations were located within the dust ZOI but were much closer to dust-generating Mine activities than AEMP stations and, therefore, had the potential to be more influenced by dust deposition than the AEMP stations. Mean TP concentrations at these stations were similar to those measured in other areas of Lac de Gras, and were also below the upper bound of the normal range. Chlorophyll *a* concentrations at these stations were also less than those measured at nearby AEMP stations (i.e., MF3-1 to MF3-4), and were at or below the lower bound of the normal range. Instead of TP and chlorophyll *a* concentrations being higher at these SES stations due to higher dust deposition, concentrations were consistent with the overall declining trends away from the effluent diffusers. The Dust SES also concluded that although the Mine effluent and dustfall samples have distinct geochemical signatures, the signature of lake water is similar to that of effluent, and the influence of dust could not be differentiated from that of effluent.
- The *2017 to 2019 Aquatic Effects Re-evaluation Report* (Golder 2020b) estimated phosphorus input from dust under the annual worst-case loading condition (i.e., spring break-up) at AEMP sampling stations within and outside the dust ZOI. Calculations indicated that adding all TP and SRP deposited to snow during the ice-cover season to the lake at spring break-up would likely result in negligible to small increases in TP and SRP in lake water, within and outside the dust ZOI. In addition, only a portion of the added phosphorus would remain in the water column and be bioavailable. It is known from analysis of AEMP biological data, that the input of phosphorus from continuous effluent discharge typically results in only a small area with detectable increases in phosphorus concentration, because the added phosphorus is quickly utilized by phytoplankton in this oligotrophic lake. Similarly, the bioavailable portion of the phosphorus load from dust during spring break-up is expected to be quickly taken up by algae and would not be available beyond a short period after break-up. Open-water season phosphorus loading from dust deposition is diffuse and episodic and would be even less likely to result in a measurable increase in phosphorus concentrations in lake water or a biological effect.

In summary, despite the estimated large contribution of TP from dust relative to other sources, the 2020 AEMP provided no evidence that dust deposition had an additional measurable effect on concentrations of TP or chlorophyll *a* in Lac de Gras, beyond the effect apparent from the Mine effluent discharge. The usefulness of continuing to calculate TP load from dust is questionable; the resulting estimate appears to consistently overestimate the contribution of TP in dust to nutrient enrichment in the lake. The AEMP sampling design provides sufficient and appropriate data to evaluate the effects in Lac de Gras from all Mine-related sources, including dustfall.

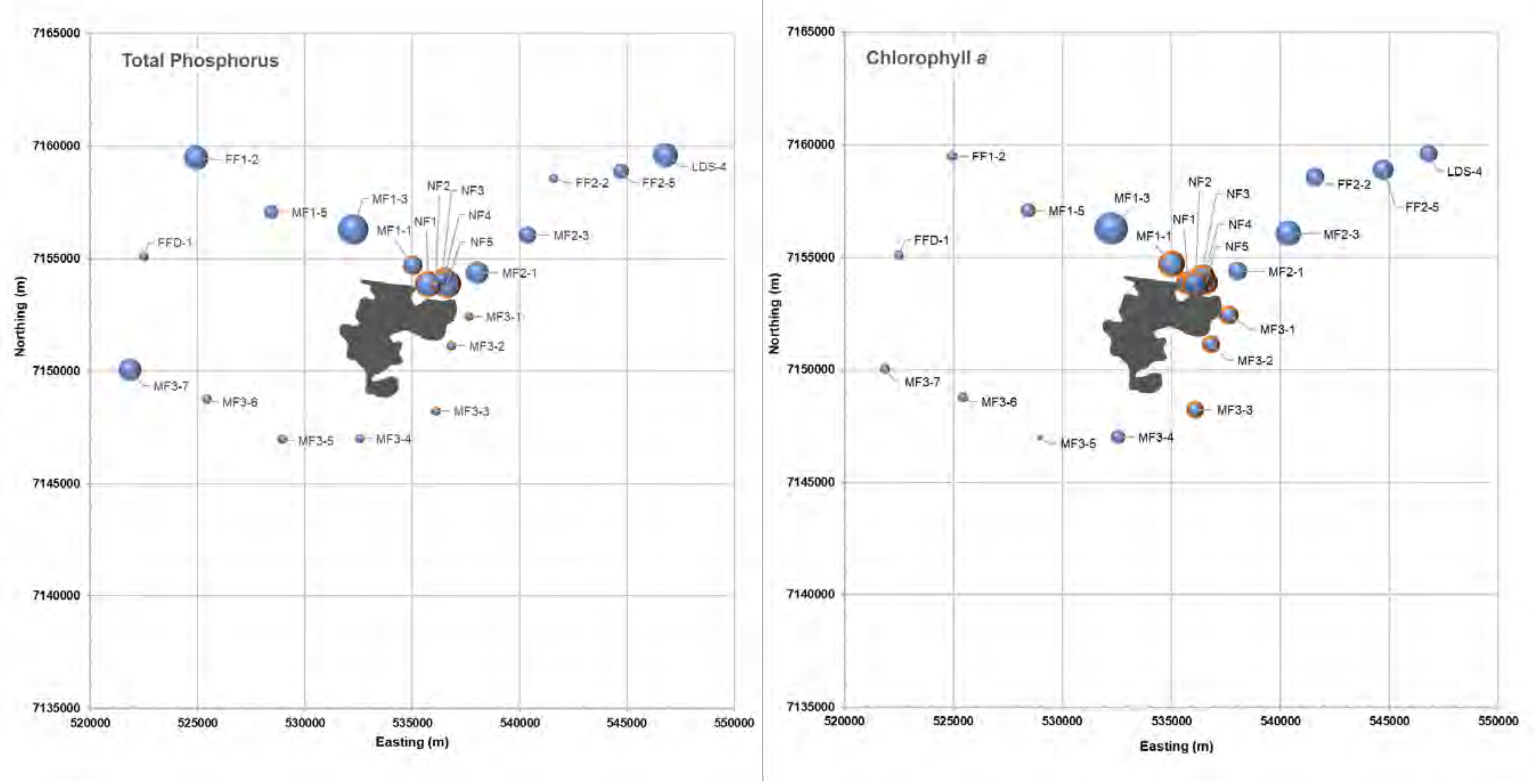
Figure 3-38 Concentrations of Total Phosphorus and Chlorophyll *a* in Lac de Gras in Relation to Dust Deposition during the Open-water Season, 2020



Note: MF stations in the zone of influence from dust deposition are labelled (i.e., MF1-1, MF3-1, MF3-2, MF3-3); all NF stations are within the zone of influence.

µg-P/L = micrograms phosphorus per litre; µg/L = micrograms per litre; NF = near-field; MF = mid-field; FF = far-field.

Figure 3-39 Concentrations of Total Phosphorus and Chlorophyll *a* in Lac de Gras during the Open-water Season in Relation to the Mine Footprint Boundary, 2020

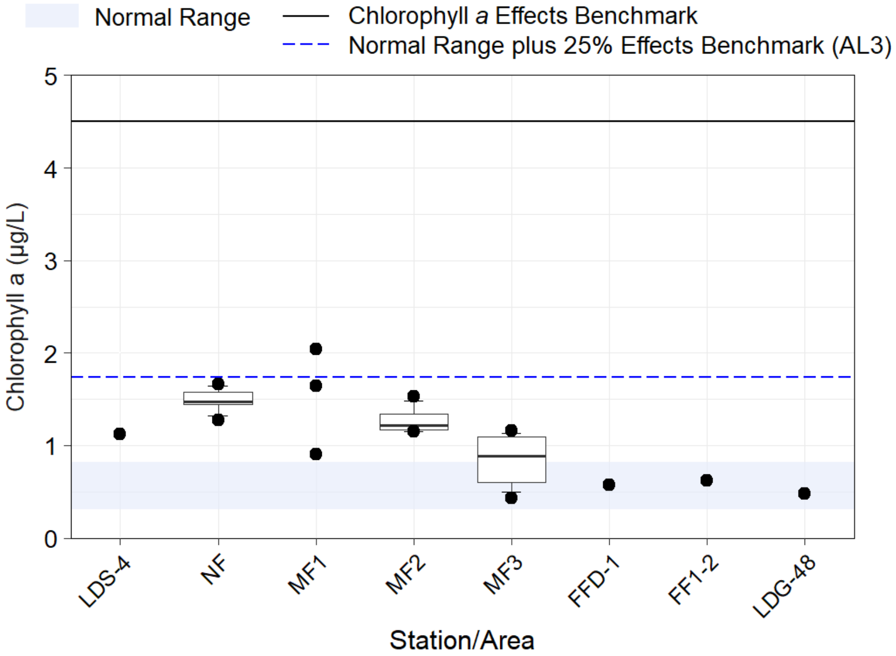


Note: Bubble size indicates relative total phosphorus concentrations among all AEMP stations. Mine footprint and location on plots are approximate. AEMP stations in the zone of influence from dust deposition are outlined in orange (i.e., all NF stations, MF1-1, MF3-1, MF3-2, MF3-3).
NF = near-field; MF = mid-field; FF = far-field.

3.3 Action Level Evaluation

The 2020 eutrophication indicators results indicate that Action Level 2 has been triggered (i.e., the chlorophyll *a* concentrations in the NF and MF areas were above the normal range [0.82 µg/L] in an area representing more than 20% of the lake) (Table 3-5). In 2020, 22% of the lake area had chlorophyll *a* concentrations above the normal range (Figure 3-35; Table 3-5). Concentrations of chlorophyll *a* remained below the 25% of the Effects Benchmark value of 1.74 µg/L at all stations except MF1-3[4] (Figure 3-40). Therefore, Action Level 3 has not been triggered for chlorophyll *a*.

Figure 3-40 Concentrations of Chlorophyll *a* by Area in Lac de Gras, 2020



Notes: Boxplots represent the 10th, 25th, 50th (i.e., median), 75th, and 90th percentile concentrations in each sampling area. The black dots in the boxplots represent the 5th (on the bottom) and 95th (on the top) percentiles, except in cases with three or less data points, where the reported values are shown.

µg/L = micrograms per litre; LDS-4 = Lac du Sauvage outlet (the Narrows); NF = near-field; MF = mid-field; FF = far-field; LDG-48 = Lac de Gras outlet.

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[4] Although the MF1-3 chlorophyll *a* concentration was greater than the Effects Benchmark of 1.74 µg/L, as presented in Table 3-5, 0% of the lake was considered >1.74 µg/L because all concentrations in the NF area were <1.74 µg/L and the chlorophyll *a* concentration at MF1-3 was identified as a statistical outlier in the gradient analysis (Section 3.2.5.3, Figure 3-29).

Table 3-5 Action Levels Classification for Chlorophyll *a*, 2020

Action Level	Action Level Classification				2020 Assessment		Action Level Triggered?
	Magnitude of Effect	Extent of Effect	Description	Value (µg/L)	Value (µg/L)	Extent of Effects	
1	Top of normal range[(a)]	MF station	95th percentile of MF values greater than normal range[(a)]	0.82	1.78	MF area	Y
2	Top of normal range[(a)]	20% of lake area or more	NF and MF values greater than normal range[(a)]	0.82	>0.82	22% of lake	Y
3	Normal range plus 25% of Effects Benchmark[(b)]	20% of lake area or more	NF and MF values greater than normal range plus 25% of Effects Benchmark[(b)]	1.74	<1.74	0% of lake	N
4	Normal range plus 50% of Effects Threshold[(c)]	20% of lake area or more	NF and MF values greater than normal range plus 50% of Effects Threshold[(c)]	-[(d)]	-[(d)]	-[(d)]	N
5	Effects Threshold	20% of lake area or more	NF and MF values greater than Effects Threshold	-[(d)]	-[(d)]	-[(d)]	N
6	Effects Threshold + 20%	20% of lake area or more	NF and MF values greater than Effects Threshold +20%	-[(d)]	-[(d)]	-[(d)]	N
7	Effects Threshold + 20%	All MF stations	95th percentile of MF values greater than Effects Threshold +20%	-[(d)]	-[(d)]	-[(d)]	N
8	Effects Threshold + 20%	FFB	95th percentile of FFB values greater than Effects Threshold +20%	-[(d)]	-[(d)]	-[(d)]	N
9[(e)]	Effects Threshold + 20%	FFA	95th percentile of FFA values greater than Effects Threshold+20%	-[(d)]	-[(d)]	-[(d)]	N

a) The normal range for chlorophyll *a* was obtained from the *AEMP Reference Conditions Report, Version 1.4* (Golder 2019a).

b) Indicates 25% of the difference between the Effects Benchmark (i.e., 4.5 µg/L) and the top of the normal range.

c) Indicates 50% of the difference between the Effects Threshold and the top of the normal range.

d) Undefined, because the Effects Threshold has not been established.

e) Although the Significance Threshold is not an Action Level, it is shown as the highest Action Level to demonstrate escalation of effects towards the Significance Threshold.

n/a = not applicable; N = no; - = undefined, because the Effects Threshold has not been established; NF = near-field; MF = mid-field; FF = far-field.

4 SUMMARY AND DISCUSSION

During 2020, phosphorus loads to Lac de Gras and phosphorus concentrations in effluent tended to be variable throughout the year. The annual TP load in 2020 was 289 kg, which was comparable to the 2019 annual load of 279 kg and was less than both the monthly and average annual loading criteria of 300 kg/mo and 1,000 kg/yr, respectively, defined in the Water Licence. Concentrations of TP, TDP and SRP in effluent were generally greater during the ice-cover season, which resulted in greater monthly loads. However, monthly loads of TP and SRP were greatest in May compared to the other months, whereas TDP loads were similar throughout the ice-cover season. Patterns in phosphorus concentrations at the mixing zone boundary generally reflected patterns observed in the Mine effluent.

Concentrations and loads of TN, nitrate, and nitrite in effluent tracked closely together, and followed a similar trend to effluent volume. Most of the TN was present as nitrate in the effluent. Monthly loads and concentrations of TN and nitrate in effluent were lowest during the ice-cover season and gradually increased from April to August. Trends for nitrite were similar, but with less of a decline from August to October. For TN and nitrate, concentrations at the mixing zone boundary were approximately equal between seasons, whereas nitrite concentrations were greater, following the trends in the effluent. Total ammonia monthly loads and concentrations in effluent did not follow the same pattern as the other nitrogen species. Loads generally followed the pattern in effluent volume for most months. Concentrations in effluent showed a steady increase starting in April and peaked in June. Concentrations at the mixing zone boundary generally followed those in effluent, except during the open-water season where mixing zone concentrations were low and effluent concentrations were variable. The sharp decreases in concentrations of TN, nitrate, nitrite, and total ammonia between July and August at the mixing zone boundary likely reflect quick assimilation by algae and bacterial nitrification (Wetzel 2001).

Secchi depth measurements showed good light penetration in all areas of Lac de Gras, indicating that a large proportion of the total volume of Lac de Gras was within the euphotic zone, and supports phytoplankton growth. Secchi depth along all MF transects appeared to increase with increasing distance from the effluent discharge, which is consistent with reduced Secchi depth due to greater phytoplankton biomass in the water column closer to the diffusers.

Phosphorus and nitrogen enter Lac de Gras from Mine effluent throughout the year; however, seasonal cycles are apparent in nutrient concentrations in effluent (Section 3.1). Phosphorus concentrations at the mixing zone boundary and in the lake were somewhat similar between seasons, although more frequently detected during ice-cover. Phosphorus concentrations continued to be low in 2020, as observed in 2019, likely due to the lower phosphorus load from effluent. Phosphorus concentrations in the lake were below the normal range at all stations and, therefore, the lake area affected was 0%. Nitrogen species had concentrations that were greater during the ice-cover season compared to the open-water season. Concentrations of TN were greater in the NF area, generally greater than normal range, and decreased with distance from the diffuser. Lake area affected for TN was smaller than in 2019, at greater than or equal to 48%, although subject to uncertainty in the effect boundary at the end of the MF3 transect. Seasonal differences in SRSi were observed, with greater concentrations during the ice-cover season compared to the open-water season. Concentrations were greater in the NF area, and decreased with distance from diffuser. The lower concentrations of dissolved inorganic nutrients (i.e., total ammonia, nitrate + nitrite, SRSi) in Lac de Gras during the open-water season likely reflect quick assimilation of nutrients by bacteria and algae (Wetzel 2001).

Despite low nutrient concentrations compared to a number of previous years, a Mine-related nutrient enrichment effect on the primary producers in Lac de Gras was evident in 2020, as indicated by the gradient analysis results and spatial trends apparent along transects sampled in Lac de Gras. Chlorophyll *a* concentrations and zooplankton biomass were greater in the NF area and decreased with distance from the diffuser, and concentrations were above the normal range in the NF area and at most stations in the MF areas. Lake area affected was 22% for chlorophyll *a* and 57% for zooplankton biomass. The effect on total phytoplankton biomass was similar, with decreasing trends with distance from the diffuser. Total phytoplankton biomass was generally within the normal range, except in the NF area, and thus the lake area affected was estimated as 2.8%.

The combined results of nutrient–productivity indicator relationships, year-to-year variation in affected areas for nutrients and productivity indicators, and nutrient ratios calculated previously (Golder 2020b) suggest at most a limited influence of nitrogen loading from the Mine effluent on the spatial extent of effects on primary producers in Lac de Gras.

The 2020 AEMP provided no evidence that dust deposition had an additional measurable effect on concentrations of TP or chlorophyll *a* in Lac de Gras, beyond the effect apparent from the Mine effluent discharge.

5 RESPONSE FRAMEWORK

Current conditions indicate that Action Level 2 has been triggered for eutrophication indicators based on chlorophyll *a* (Section 3.3). Action Level 2 was triggered because the chlorophyll *a* concentrations in the NF and MF areas are greater than the upper limit of the normal range (0.82 µg/L) in an area representing more than 20% of the lake (Table 3-5). Action Level 3 was not triggered in 2020 because concentrations of chlorophyll *a* remained below 25% of the Effects Benchmark of 1.74 µg/L at all stations except MF1-3. An Effects Benchmark has already been established for chlorophyll *a* (i.e., 4.5 µg/L), per the requirements of trigging an Action Level 2 previously, as presented in *AEMP Design Plan Version 4.1* (Golder 2017a). Therefore, no further action is required.

6 CONCLUSIONS

This report presents the assessment of data collected by DDMI for the eutrophication indicators component of the 2020 AEMP. Results of the 2020 eutrophication assessment indicate the following:

- The Mine is having a nutrient enrichment effect in Lac de Gras[5], as evidenced by greater nutrient and chlorophyll *a* concentrations, and phytoplankton and zooplankton biomass in the NF area, compared to the rest of the lake.
- TP, TDP, and SRP concentrations were within or below the normal range throughout most of Lac de Gras during both the ice-cover and open-water seasons. The lower phosphorus concentrations in lake water relative to previous years were at least partly due to the lower TP loads from Mine effluent in 2020.

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[5] This is consistent with observations reported in previous AEMP years as summarized in the *2017 to 2019 Aquatic Effects Re-evaluation Report* (Golder 2020b) and subsequent AEMP annual reports (Golder 2018, 2019c, 2020c).

- Nitrogen concentrations were above the normal range in a large proportion of Lac de Gras, with significant decreasing concentrations with distance from the diffusers.
- Along most transects, a significant decreasing trend in SRSi concentration was observed, indicating a Mine effect.
- Chlorophyll *a* concentrations and zooplankton biomass decreased with distance from the diffuser and were above the normal range in the NF area and most stations in the MF areas. Total phytoplankton biomass decreased with distance from the diffuser; however, most results were within the normal range.
- The spatial extent of effects on eutrophication indicators in 2020 varied from 0% to 57% of the lake area depending on indicator[6]:
    - The extent of effect was 0% for TP, and 40% to ≥48% of the lake area for TN, depending on season.
    - The extent of effect was 22% for chlorophyll *a* concentration, 2.8% for phytoplankton biomass and 57% of the lake area for zooplankton biomass.
- Chlorophyll *a* in Lac de Gras were weakly correlated with TP and strongly correlated with TDS and SRSi. There was no relationship between TN and chlorophyll *a*.
- All evidence indicates that effluent is the main source of Mine effects on Lac de Gras, with a negligible contribution from dust deposition. This conclusion is consistent with the results of the 2019 Dust SES, which did not detect a dust-related chemical signature in lake water and suggested limited bioavailability of phosphorus in dust.
- The magnitude and extent of effects on chlorophyll *a* triggered Action Level 2, which was consistent with observations reported in previous AEMP years as summarized in the *2017 to 2019 Aquatic Effects Re-evaluation Report* (Golder 2020b); either Action Level 1 or 2 were triggered in the 2007 to 2018 AEMPs, and no Action Level was triggered in 2019.
- The 2020 results are consistent with the EA prediction of greater concentrations of nutrients, particularly phosphorus from the minewater discharge, resulting in an increase in primary productivity in Lac de Gras.

Overall, the conclusions from the 2020 AEMP are consistent with those reported in previous AEMPs, in that the Mine is having a nutrient enrichment effect in Lac de Gras, inputs of phosphorus appear to be the main driver to increases in primary productivity, and the main source of Mine-related effects on eutrophication indicators is the effluent. Action Level 2 was triggered; however, given the establishment of an Effects Benchmark in the *AEMP Design Plan Version 4.1* (Golder 2017a), no further action is required based on the 2020 monitoring results.

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[6] This is consistent with observations reported in previous AEMP years as summarized in the *2017 to 2019 Aquatic Effects Re-evaluation Report* (Golder 2020b) and subsequent AEMP annual reports (Golder 2018, 2019c, 2020c); extent of effects for TP has been low and variable and <20%, for chlorophyll *a* has been variable and <45%, for TN has been greater than 40% since 2014, and for plankton has been variable.

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8 CLOSURE

We trust the information in this report meets your requirements at this time. If you have any questions relating to the information contained in this report, please do not hesitate to contact the undersigned.

GOLDER ASSOCIATES LTD.

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ATTACHMENT A

AEMP SAMPLING SCHEDULE

Table A-1 2020 AEMP Sampling Schedule

Sites	Ice-cover										Open-water									
	April									May	August									September
	20	21	22	23	25	26	27	28	29	1	16	18	19	21	22	27	28	29	31	7
NF1								N												Np
NF2		N																		Np
NF3	N(b)																			Np
NF4								N										Np(c)		
NF5										N								Np		
MF1-1		N(c)																	Np(c)	
MF1-3		N																	Np	
MF1-5			N(c)																Np	
MF2-1							N										Np			
MF2-3										N							Np			
FF2-2									N				Np(d)							
FF2-5									N(c)				Np							
MF3-1							N(c)										Np			
MF3-2							N									Np				
MF3-3					N										Np					
MF3-4						N									Np					
MF3-5						N								Np						
MF3-6						N								Np						
MF3-7				N										Np						
FF1-2(a)			N									Np(c)								
FFD-1(a)				N(c)								Np								
LDG-48(a)					N						Np(e)									
LDS-4(a)											Np(e)									

Notes:
a) Discrete samples were collected at mid-depth.
b) Quality control samples were collected for total ammonia BV Labs only
c) Quality control samples were collected for total ammonia BV Labs and total ammonia ALS only.
d) Quality control samples were collected for total ammonia ALS only.
e) Only chlorophyll *a* was sampled, not plankton.
If a quality control sample was collected at the same time as the Nutrient sample, then the “N” was colour-coded: Equipment Blank (EB), Field Blank (FB), Travel Blank (TB), and Field Duplicate (FD).
N = nutrient sample collected; p = chlorophyll *a* and plankton sample collected; NF = near-field; MF = mid-field; FF = far-field; LDG = lac de Gras; LDS = Lac du Sauvage.

ATTACHMENT B

ANOMALOUS DATA SCREENING

ANOMALOUS DATA SCREENING

Methods

Data screening is the initial phase of data handling when analyzing chemistry datasets, which are subject to occasional extreme values that are frequently incorrect, reflecting field or laboratory errors, data transcription or calculation errors, or extreme natural variability. This initial step is undertaken to verify that the data quality objectives (DQO) established by the Quality Assurance Project Plan Version 3.1 (QAPP; Golder 2017) and the AEMP study design have been met. The purpose of this step is to initially identify unusually high or low values (i.e., anomalous data), correct them if possible, and make a decision whether to retain or exclude remaining anomalous data from further analysis.

Initial screening of the 2020 nutrient, chlorophyll *a*, and zooplankton biomass (as ash free dry mass) datasets was completed before data analyses to identify unusually high (or low) values and decide whether to retain or exclude anomalous data from further analysis. The anomalous data screening methods are described in the QAPP (Golder 2017).

Results

Data screening for anomalous values in the 2020 dataset identified three anomalous values in the dataset, representing 0.1% of the total data (Table B-1). In cases where unusual values were identified, scatterplots were generated to allow a visual review of anomalous data and to provide transparency (Figures B-1 and B-2). This review indicated that spatial trends were largely absent from the affected datasets, and the anomalous values identified by numerical screening were highly unusual. Therefore, the three anomalous values were excluded from further analysis.

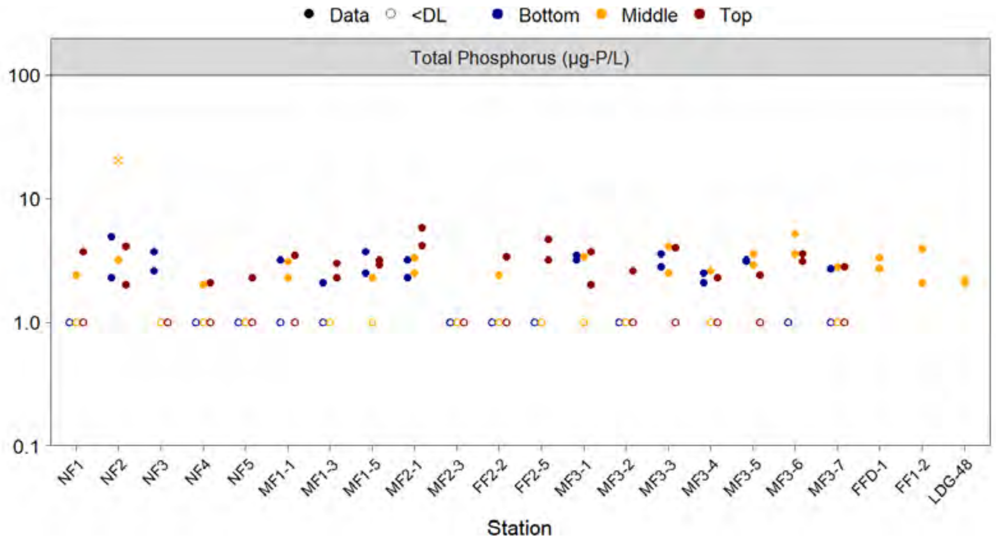
Table B-1 List of Anomalous Values Removed from the Eutrophication Dataset, 2020

Variable	Unit	Season	Station	Value	Standard Deviation Distance[(a)]
Dissolved Kjeldahl Nitrogen	µg-N/L	Open-water	FF2-5	310	4.5
Total Phosphorus	µg-P/L	Ice-cover	NF2-M	20.4	8.9
Total Phosphorus	µg-P/L	Open-water	MF2-1	9.9	4.7

a) Number of standard deviations from the mean calculated for the 2020 monitoring period.

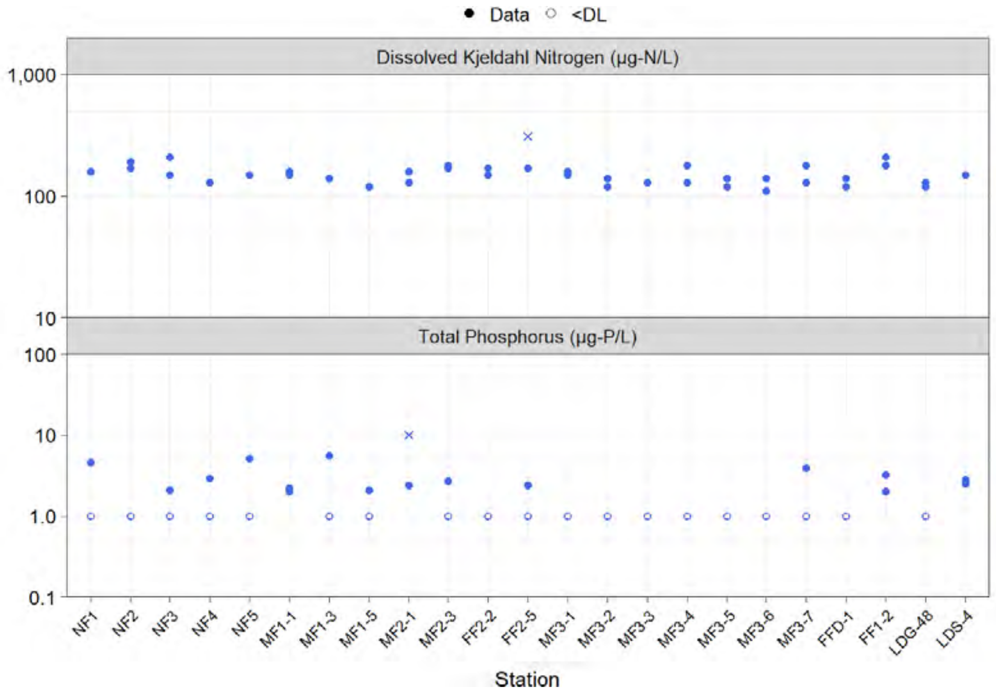
µg-N/L = micrograms nitrogen per litre; µg-P/L = micrograms phosphorus per litre; FF = far-field; NF = near-field; MF = mid-field.

Figure B-1 Anomalous Data Removed from AEMP Analyses Conducted for Total Phosphorus during the Ice-cover Season, 2020



µg-P/L = micrograms phosphorus per litre; < = less than; DL = detection limit; NF = near-field; MF = mi-field; FF = far-field; LDG-48 = Lac de Gras outlet; LDS-4 = Lac du Sauvage Outlet (the Narrows).

Figure B-2 Anomalous Data Removed from AEMP Analyses Conducted for Dissolved Kjeldahl Nitrogen and Total Phosphorus during the Open-water Season, 2020



µg-N/L = micrograms nitrogen per litre; µg-P/L = micrograms phosphorus per litre; < = less than; DL = detection limit; NF = near-field; MF = mi-field; FF = far-field; LDG-48 = Lac de Gras outlet; LDS-4 = Lac du Sauvage Outlet (the Narrows).

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ATTACHMENT C

QUALITY ASSURANCE AND QUALITY CONTROL

QUALITY ASSURANCE AND QUALITY CONTROL

Quality assurance and quality control (QA/QC) practices determine data integrity and are relevant to all aspects of a study, from sample collection to data analysis and reporting and are described in the Quality Assurance Project Plan Version 3.1 (QAPP; Golder 2017). Quality assurance encompasses management and technical practices designed to generate consistent, high quality data. Quality control is an aspect of quality assurance and includes the techniques used to assess data quality and the corrective actions to be taken when the data quality objectives are not met. This Attachment describes QA/QC practices applied during the 2020 eutrophication indicators component of the Aquatic Environment Monitoring Program (AEMP), evaluates quality control (QC) data, and describes the implications of QC results to the interpretation of study results.

Quality Assurance

Field Staff Training and Operations

Diavik Diamond Mines (2012) Inc. (DDMI) field staff are trained to be proficient in standardized field sampling procedures, data recording, and equipment operations applicable to water quality sampling. Field work was completed according to specified instructions and standard operating procedures (SOP). The procedures are described in:

- ENVI-923-0119 “AEMP SOP Combined Open-Water and Ice-Cover”
- ENVI-902-0119 “SOP Quality Assurance Quality Control”
- ENVI-900-0119 “SOP Chain of Custody”

These SOPs include guidelines for field record-keeping and sample tracking, guidance for use of sampling equipment, relevant technical procedures, and sample labelling, shipping and tracking protocols.

Laboratory

Quality assurance at the DDMI Environmental Laboratory encompasses all quality-related activities related to aquatic testing and analysis, and relevant technical support (ENVI-902-0119 “SOP Quality Assurance Quality Control”).

DDMI’s quality assurance places an emphasis on four aspects:

- infrastructure (instruments, testing capabilities, calibrations, SOPs)
- control measures (internal/external)
- personnel (competence, ethics, and integrity)
- data management

Nutrient samples, excluding soluble reactive silica (SRSi), were sent for analysis to Bureau Veritas Laboratories (BV Labs; formerly Maxxam Analytics), Edmonton or Calgary, Alberta, a laboratory accredited by the Canadian Association of Laboratory Accreditation (CALA). All open-water samples were analyzed by BV Labs in Edmonton; the ice-cover samples were divided between the two locations. Separate samples for total ammonia analysis were also sent to ALS Laboratories (ALS) in Vancouver; ALS is also a CALA accredited laboratory. SRSi samples were only sent to ALS in Vancouver. Nutrient analysis followed standard analytical methods. Under the accreditation program, performance assessments are completed annually for laboratory procedures, analytical methods, and internal quality control.

Chlorophyll *a* samples were sent to the Biogeochemical Analytical Service Laboratory at the University of Alberta, Edmonton, Alberta, and analyzed by fluorometric analysis.

Zooplankton biomass (as ash free dry mass [AFDM]) samples were submitted to BV Labs and analyzed by gravimetric analysis. A quality assurance issue occurred prior to analysis whereby the laboratory accidentally took an aliquot of approximately 60 mL from all but four zooplankton bottles to use for a different analysis. The removal of this aliquot had the potential to remove zooplankton from the original sample and thus could result in zooplankton biomass estimates that were biased low. The affected sample bottles were not shaken before the aliquot was taken. The analyst noted the presence of sludge/particulate matter on the bottom of the zooplankton bottles and decanted water without shaking or mixing the samples. Some re-suspension of the particulate matter may have occurred when moving the samples from one part of the laboratory to the other prior to decanting. When the error in sample handling was discovered, the laboratory contacted DDMI.

To evaluate the influence of the aliquot removal on zooplankton biomass, the four unimpacted samples were treated the same way as the other impacted samples, with the exception that the decanted aliquots were analyzed separately for zooplankton biomass. It was assumed that the results from these four samples provided a reasonable estimate of the bias in the other samples. The results suggest that there was very little zooplankton present in the removed aliquots (i.e., <2% of the total zooplankton biomass; Table C-1). A 2% bias is unlikely to be distinguishable from other sources of variability (e.g., variability between field duplicates, or between years) and thus is not expected to affect the interpretation of results for this parameter. Therefore, the AFDM results were not corrected for this bias before other analyses.

Table C-1 Comparison Between Decanted Aliquot and Remaining Sample for Total Zooplankton Biomass as AFDM, 2020

Unimpacted Sample	Zooplankton Biomass as AFDM (mg/m^3)			Fraction of total zooplankton biomass present in aliquot
	60 mL aliquot decanted from top of sample	Remaining sample (shaken prior to analysis)	Sum	
NF2-4	1.08	54.70	55.79	1.94%
NF2-5	0.52	60.74	61.26	0.85%
FF1-2-4	0.38	45.55	45.93	0.82%
FF1-2-5	0.45	48.78	49.23	0.91%

Note: Sums may not align exactly due to number rounding.

Field and Office Operations

A quality assurance system was established as an organized system of data control, analysis and filing. Relevant elements of this system are as follows:

- pre-field meetings to discuss specific work instructions with field crews
- field crew check-in with task managers every 24 to 48 hours to report work completed during that period

- designating two crew members responsible for:
    - collecting all required samples
    - downloading and storing electronic data
    - completing chain-of-custody and analytical request forms; labelling and documentation
    - processing, where required, and delivering samples to analytical laboratory in a timely manner
- cross-checking chain-of-custody forms and analysis request forms by the task manager to verify that the correct analysis packages had been requested
- review of field sheets by the task manager for completeness and accuracy
- reviewing laboratory data immediately after receipt from the analytical laboratory
- creating backup files before data analysis
- completing appropriate logic checks and verifying accuracy of calculations

Quality Control

Methods

Quality control is a specific aspect of quality assurance that includes the techniques used to assess data quality. The field QC program consisted of the collection of field blanks, equipment blanks, travel blanks, and duplicate samples. The blanks are used to assess potential sample contamination in the field, and the duplicates are used to assess within-station variation and sampling precision. Field, travel, and equipment blank samples were collected during both the open-water and ice-cover seasons. All stations and parameters were sampled in duplicate. In addition, duplicate samples for total ammonia analysis were submitted to both BV Labs and ALS. As discussed in the *Effluent and Water Chemistry Report* (Appendix II), total ammonia data from ALS was used in the eutrophication indicators data analysis.

Field, Travel, and Equipment Blanks

Blanks contained de-ionized water obtained from the laboratory. Field blanks consisted of samples prepared in the field. Equipment blanks were exposed to all aspects of sample collection and analysis, including the procedures used in the field, and contact with all sampling devices and other equipment. Travel blanks were transported with the crew during daily sampling procedures and remained unopened during field sampling. Blanks were submitted blind to the laboratory for the same analyses as the field samples. Equipment and travel blanks provide information regarding potential sample contamination from equipment or sample transport.

The field, travel, and equipment blanks were also used to detect potential contamination during collection, shipping, and analysis. Although concentrations should be below DLs in these blanks, detected concentrations were considered notable if they were greater than five times the corresponding DL. This threshold is based on the Practical Quantitation Limit defined by the United States Environmental Protection Agency (US EPA 1994, 2007; BC MOE 2009), which takes into account the potential for data accuracy errors when variable concentrations approach or are below DLs.

Notable results observed in the field blanks were evaluated relative to analyte concentrations observed in the field samples to evaluate whether sample contamination was limited to the QC sample or was apparent in other samples as well. Where, based on this comparison, sample contamination was not an isolated occurrence, the field data were flagged and interpreted with this limitation in mind.

Duplicate Samples

Duplicate samples consisted of two samples collected from the same location at the same time, using the same sampling and sample handling procedures. They were labelled and preserved individually and submitted separately to the analytical laboratory for identical analyses. Duplicate samples were used to check within-station variation and the precision of field sampling and analytical methods. Differences between concentrations measured in duplicate water samples were calculated as the relative percent difference (RPD) for each variable. Before calculating the RPD, concentrations below the DL were replaced with 0.5 times the DL value. Substitution with half the DL is a common approach used to deal with censored data (US EPA 2000) and is consistent with the approved methods applied in the calculation of the normal range in the *AEMP Reference Conditions Report Version 1.4* (Golder 2019). The RPD was calculated using the following formula:

RPD = (|difference in concentration between duplicate samples| / mean concentration) x 100

The RPD value for a given variable was considered notable if both conditions were true:

- it was greater than 40%
- concentrations in one or both samples were greater than or equal to five times the DL

These criteria were approved as part of the QAPP (Golder 2017).

The number of variables which exceeded the assessment criteria was compared to the total number of variables analyzed to evaluate analytical precision. The analytical precision was rated as follows:

- high, if less than 10% of the total number of variables were notably different from one another
- moderate, if 10% to 30% of the total number of variables were notably different from one another
- low, if more than 30% of the total number of variables were notably different from one another

Total Versus Dissolved Forms

The concentrations of total nitrogen (TN), total Kjeldahl nitrogen (TKN), and total phosphorus (TP) consist of both particulate and dissolved forms of the analyte. Thus, total dissolved nitrogen (TDN), dissolved Kjeldahl nitrogen (DKN), and total dissolved phosphorus (TDP) should be equal to or less than the total concentrations. Typically, the RPD between the two forms should not exceed 20%. If the RPD was found to be greater than 20% and one or both of the samples were greater than or equal to five times the DL, these data were flagged, and the validity of the data was investigated.

Results

Detection Limits

In general, achieved DLs were the same as target DLs, with the exception of a few samples (Table C-2).

For TDN, most samples (i.e., 177 samples, including QC samples) were analyzed at the target DL of 20 µg/L, but 5 samples were analyzed at a DL of 40 µg/L and 1 sample at 100 µg/L. For DKN, most samples (i.e., 177 samples, including QC samples) were analyzed at the target DL of 20 µg/L, but 5 samples were analyzed at a DL of 40 µg/L and 1 sample at 100 µg/L. Since TN is the more useful variable for evaluating effects related to nutrient enrichment, and there were data for multiple nutrient species to support the interpretation of results, these deviations from target DLs were considered unlikely to affect the overall conclusions of the assessment.

The target DL for SRSi is set at 5 µg/L; however, upon consultation with the analytical laboratory, the lowest achievable DL is 10 µg/L (O. Gregg, personal communication 14 Jan 2021). An update will be made to the SRSi DL in the next AEMP design plan update. Most samples in 2020 were analyzed at a DL of 10 µg/L (184 samples, which include QC samples). A total of 10 samples were analyzed at a DL of 50 µg/L. This year (2020) is the second year that this variable has been added to the analytical suite, and significant declining trends in SRSi concentrations with distance from diffuser were identified (see Section 3.2.5.2 of the main appendix). It is unlikely that the raised DL impaired interpretation of the results or that the overall conclusions of the assessment would be different with lower DLs.

Table C-2 Target and Achieved Detection Limits, 2020

Variable	Unit	Target DL	Achieved DL for Most Samples	Other DL	Sample	Sample Type	Season
Total Phosphorus	µg-P/L	2	2	n/a			
Total Dissolved Phosphorus	µg-P/L	2	2	n/a			
Soluble Reactive Phosphorus	µg-P/L	1	1	n/a			
Total Nitrogen	µg-N/L	20	20	n/a			
Total Dissolved Nitrogen	µg-N/L	20	20	40	NF2B-4	N	IC
				40	NF2B-5	N	IC
				40	NF2M-4	N	IC
				40	NF2M-5	N	IC
				100	NF4-B-4	N	IC
				40	MF1-3T-4	N	IC
				200	NF1-5	N	OW
Total Kjeldahl Nitrogen	µg-N/L	20	20	n/a			

Table C-2 Target and Achieved Detection Limits, 2020 (continued)

Variable	Unit	Target DL	Achieved DL for Most Samples	Other DL	Sample	Sample Type	Season
Dissolved Kjeldahl Nitrogen	µg-N/L	20	20	40	NF2B-4	N	IC
				40	NF2B-5	N	IC
				40	NF2M-4	N	IC
				40	NF2M-5	N	IC
				100	NF4B-4	N	IC
				40	MF1-3T-4	N	IC
				200	NF1-5	N	OW
Nitrate	µg-N/L	2	2	n/a			
Nitrite	µg-N/L	1	1	n/a			
Nitrate + Nitrite	µg-N/L	2	2 or 2.2[(a)]	n/a			
Total Ammonia (BV Labs)	µg-N/L	5	5	n/a			
Total Ammonia (ALS)	µg-N/L	5	5	n/a			
Soluble Reactive Silica	µg/L	5	10	50	MF1-5B-4-5	N	IC
					MF2-1B-4-5	N	IC
					MF3-4B-5	N	IC
					NF1B-4-5	N	IC
					NF2B-4-5	N	IC
					NF2M-4-5	N	IC
					NF3B-4-5	N	IC
					NF4B-4-5	N	IC
					NF5B-4-5	N	IC
					NF1-5	N	OW

Note: DL = detection limit; µg-P/L = micrograms phosphorus per litre; µg-N/L = micrograms nitrogen per litre; NF = near-field; MF = mid-field; N = normal (field) sample; IC = ice-cover; OW = open-water; n/a = not applicable.

(a) All IC samples met target DL of 2 µg/L; all OW samples had DL of 2.2 µg/L

Field, Travel, and Equipment Blanks

Twelve travel blanks, 10 equipment blanks, and 10 field blanks were collected during the 2020 AEMP eutrophication indicators component; 18 blank samples were collected during the ice-cover season (Table C-3) and 14 blank samples were collected during the open-water season (Table C-4). Of these 32 blanks, 14 were analyzed for all nutrient variables (8 blanks during ice-cover season and 6 during open-water season), and 18 blanks were only analyzed for total ammonia (duplicate samples at BV Labs and ALS; 10 blanks during ice-cover season and 8 during open-water season).

During the ice-cover season, concentrations that were more than five times the DL were observed in two samples for total ammonia analyzed by ALS (equipment blank FF2-5B-1-4 and field blank MF2-1M-2-5) and four samples for total ammonia analyzed by BV Labs (travel blank NF3T-3-4, equipment blanks FF2-5B-1-4 and MF3-5B-1-5, and field blank NF1M-2-5).

- BV Labs identified a contamination issue in the ice-cover total ammonia samples.
- The total ammonia equipment blank FF2-5B-1-4 collected on 29 April 2020 and analyzed by ALS had a concentration of 46.1 µg/L. The duplicate of this blank had a lower concentration (i.e., 11.8 µg/L) that was similar to other blanks (Table C-3). Therefore, it was assumed that contamination was limited to the FF2-5B-1-4 blank.
- The total ammonia field blank MF2-1M-2-5 collected on 27 April 2020 and analyzed by ALS had a concentration of 31.5 µg/L. The duplicate of this blank had a concentration below the DL and was similar to other blanks (Table C-3). Therefore, it was assumed that contamination was limited to the MF2-1M-2-5 blank.

Fewer exceedances of data quality objectives were observed in the open-water dataset (Table C-4). Two travel blanks and two field blanks during the open-water season had total ammonia concentrations measured by BV Labs that were more than five times the DL. However, this does not affect the interpretation of results, because the open-water total ammonia data provided by ALS were used in the data analysis.

Overall, the number of notable results were small and limited to total ammonia. The results are not indicative of a systemic contamination issue.

Table C-3 Concentrations of Nutrients in Travel, Equipment and Field Blanks during the Ice-cover Season, 2020

Variable	Unit	DL	Ice-cover																	
			MF1-5B-3-4	MF1-5B-3-5	MF3-2B-3-4	MF3-2B-3-5	NF3T-3-4	NF3T-3-5	FF2-5B-1-4	FF2-5B-1-5	MF1-1B-1-4	MF1-1B-1-5	MF3-5B-1-4	MF3-5B-1-5	FFD-1M-2-4	FFD-1M-2-5	MF2-1M-2-4	MF2-1M-2-5	NF1M-2-4	NF1M-2-5
			Travel Blank	Travel Blank	Travel Blank	Travel Blank	Travel Blank	Travel Blank	Equipment Blank	Equipment Blank	Equipment Blank	Equipment Blank	Equipment Blank	Equipment Blank	Field Blank	Field Blank	Field Blank	Field Blank	Field Blank	Field Blank
			22-Apr-2020	22-Apr-2020	27-Apr-2020	27-Apr-2020	20-Apr-2020	20-Apr-2020	29 Apr 2020	29 Apr 2020	21 Apr 2020	21 Apr 2020	26 Apr 2020	26 Apr 2020	23-Apr-2020	23-Apr-2020	27-Apr-2020	27-Apr-2020	28-Apr-2020	28-Apr-2020
Total Phosphorus	µg-P/L	2	n/a	n/a	<2	<2	n/a	n/a	n/a	n/a	n/a	n/a	<2	<2	n/a	n/a	<2	<2	<2	<2
Total Dissolved Phosphorus	µg-P/L	2	n/a	n/a	<2	<2	n/a	n/a	n/a	n/a	n/a	n/a	<2	<2	n/a	n/a	<2	<2	<2	<2
Soluble Reactive Phosphorus	µg-P/L	1	n/a	n/a	<1	<1	n/a	n/a	n/a	n/a	n/a	n/a	<1	1	n/a	n/a	<1	<1	<1	<1
Total Nitrogen	µg-N/L	20	n/a	n/a	68	43	n/a	n/a	n/a	n/a	n/a	n/a	28	23	n/a	n/a	51	51	56	51
Total Dissolved Nitrogen	µg-N/L	20	n/a	n/a	<20	<20	n/a	n/a	n/a	n/a	n/a	n/a	<20	<20	n/a	n/a	<20	33	28	<20
Total Ammonia - ALS	µg-N/L	5	<5	<5	<5	<5	<5	6	**46.1**	11.8	<5	<5	11.7	8.7	<5	<5	<5	**31.5**	<5	10.8
Total Ammonia - BV Labs	µg-N/L	5	<5	<5	<5	<5	**39**	<5	**27**	10	5.8	6.7	8.7	**39**	8.3	<5	22	17	12	**65**
Nitrate	µg-N/L	2	n/a	n/a	<2	<2	n/a	n/a	n/a	n/a	n/a	n/a	<2	<2	n/a	n/a	<2	<2	<2	<2
Nitrite	µg-N/L	1	n/a	n/a	<1	1.5	n/a	n/a	n/a	n/a	n/a	n/a	<1	<1	n/a	n/a	<1	1.2	3.6	4.1
Nitrate + Nitrite	µg-N/L	2	n/a	n/a	<2	<2	n/a	n/a	n/a	n/a	n/a	n/a	<2	<2	n/a	n/a	<2	<2	3.6	4.1
Total Kjeldahl Nitrogen	µg-N/L	20	n/a	n/a	68	41	n/a	n/a	n/a	n/a	n/a	n/a	28	23	n/a	n/a	51	50	52	47
Dissolved Kjeldahl Nitrogen	µg-N/L	20	n/a	n/a	<20	<20	n/a	n/a	n/a	n/a	n/a	n/a	<20	<20	n/a	n/a	<20	32	25	<20
Soluble Reactive Silica	µg/L	10	n/a	n/a	<10	<10	n/a	n/a	n/a	n/a	n/a	n/a	10	10	n/a	n/a	13	12	10	<10

Notes: **Bolded** numbers indicate QC flags for concentrations that were greater than five times the corresponding DL.

µg-P/L = micrograms phosphorus per litre; µg-N/L = micrograms nitrogen per litre; DL = detection limit; < = less than; NF = near-field; MF = mid-field; FF = far-field; n/a = not applicable.

Table C-4 Concentrations of Nutrients in Travel, Equipment and Field Blanks during the Open-water Season, 2020

Variable	Unit	DL	Open-water													
			FF2-2-3-4	FF2-2-3-5	MF3-3-3-4	MF3-3-3-5	NF4-3-4	NF4-3-5	MF1-1-1-4	MF1-1-1-5	MF3-6-1-4	MF3-6-1-5	FF1-2-2-4	FF1-2-2-5	NF2-2-4	NF2-2-5
			Travel Blank	Travel Blank	Travel Blank	Travel Blank	Travel Blank	Travel Blank	Equipment Blank	Equipment Blank	Equipment Blank	Equipment Blank	Field Blank	Field Blank	Field Blank	Field Blank
			19-Aug-20	19-Aug-20	22-Aug-20	22-Aug-20	29-Aug-20	29-Aug-20	31-Aug-2020	31-Aug-2020	21-Aug-2020	21-Aug-2020	18-Aug-2020	18-Aug-2020	07-Sep-2020	07-Sep-2020
Total Phosphorus	µg-P/L	2	n/a	n/a	<2	<2	n/a	n/a	n/a	n/a	<2	<2	n/a	n/a	<2	<2
Total Dissolved Phosphorus	µg-P/L	2	n/a	n/a	<2	<2	n/a	n/a	n/a	n/a	<2	<2	n/a	n/a	<2	<2
Soluble Reactive Phosphorus	µg-P/L	1	n/a	n/a	<1	<1	n/a	n/a	n/a	n/a	<1	<1	n/a	n/a	<1	<1
Total Nitrogen	µg-N/L	20	n/a	n/a	<20	<20	n/a	n/a	n/a	n/a	<20	23	n/a	n/a	<20	<20
Total Dissolved Nitrogen	µg-N/L	20	n/a	n/a	41	60	n/a	n/a	n/a	n/a	<20	<20	n/a	n/a	<20	<20
Total Ammonia - ALS	µg-N/L	5	<5	8.7	13.7	11.9	10.9	22.3	<5	10	<5	<5	5.5	<5	<5	<5
Total Ammonia - BV Labs	µg-N/L	5	n/a	n/a	25	**49**	7.7	**48**	<5	<5	<5	6.5	<5	6.7	**130**	**73**
Nitrate	µg-N/L	2	n/a	n/a	<2	<2	n/a	n/a	n/a	n/a	<2	<2	n/a	n/a	<2	<2
Nitrite	µg-N/L	1	n/a	n/a	<1	<1	n/a	n/a	n/a	n/a	1	1.1	n/a	n/a	<1	<1
Nitrate + Nitrite	µg-N/L	2	n/a	n/a	<2.2	<2.2	n/a	n/a	n/a	n/a	<2.2	<2.2	n/a	n/a	<2.2	<2.2
Total Kjeldahl Nitrogen	µg-N/L	20	n/a	n/a	<20	<20	n/a	n/a	n/a	n/a	<20	22	n/a	n/a	<20	<20
Dissolved Kjeldahl Nitrogen	µg-N/L	20	n/a	n/a	41	60	n/a	n/a	n/a	n/a	<20	<20	n/a	n/a	<20	<20
Soluble Reactive Silica	µg/L	10	n/a	n/a	<10	<10	n/a	n/a	n/a	n/a	<10	<10	n/a	n/a	13	13

Notes: **Bolded** numbers indicate QC flags for concentrations that were greater than five times the corresponding DL.

µg-P/L = micrograms phosphorus per litre; µg-N/L = micrograms nitrogen per litre; DL = detection limit; < = less than; NF = near-field; MF = mid-field; FF = far-field; n/a = not applicable.

Nutrient Duplicate Samples

During the ice-cover season, 56 out of a total of 808 results (7%) had an RPD of more than 40% between duplicates, while having concentrations greater than five times the DL in at least one of the samples (Table C-5). Flagged results varied among locations and analytes, including TP, TN, total ammonia, nitrate, nitrate + nitrite, and TKN. However, of the flagged results, 47 of the 56 were total ammonia. Because less than 10% of the duplicate pairs were notably different from one another, the analytical precision for the ice-cover nutrient samples was rated as high.

Fewer DQO exceedances were observed during the open-water season. Out of a total of 299 results, 18 results (6%) had an RPD of more than 40% between duplicates, while having concentrations greater than five times the DL in at least one of the samples (Table C-6). As with ice-cover season, flagged results varied among locations and analytes (i.e., TDP, TN, TDN, total ammonia, TKN and DKN). Because less than 10% of the duplicate pairs were notably different from one another, the analytical precision for the ice-cover nutrient samples was rated as high.

The following results, which failed DQOs, were removed from the dataset per the following rationale:

- The reported TN and TKN values for MF3-7T-5 collected during the ice-cover season were non-detect (<20 µg-N/L) compared to their duplicates (170 µg-N/L) and failed the DQOs, with RPDs of 178%. These values were not consistent with those reported for the bottom and top depths. Sample MF3-7T-5 was re-analyzed for TN and TKN, but because the laboratory re-analyzed at a dilution, the results were variable and could not be reliably reported. Three lines of evidence suggest that this reported non-detect value was not representative of concentrations at this station: 1) there were measurable concentrations at other depths that were similar to each other; 2) there were measurable dissolved concentrations for this sample; and 2) concentrations at other depths were consistent with concentrations measured in nearby stations.
- The reported TDP value of 11.9 µg-P/L for MF3-5-5 collected during the open-water season was higher than its duplicate (<2 µg-P/L) and failed the DQO with an RPD of 169%. The sample was not re-analyzed by the laboratory. This reported TDP value was not considered representative at this station because the corresponding TP value was much lower (non-detect at detection limit of 2 µg-P/L) and consistent with other TP concentrations at nearby stations.
- The reported TDN and DKN values for NF1-5 collected during the open-water season were both 13,000 µg-N/L, which were two orders of magnitude higher than their duplicates (TDN = 220 µg-N/L, DKN = 160 µg-N/L) and the corresponding TN and TKN values (TN = 220 µg-N/L, TKN = 170 µg-N/L). The sample was not re-analyzed by the laboratory. The reported TDN and DKN values were not considered representative at this station because of the high magnitude of the concentrations relative to those measured in the field duplicate, the total nitrogen fractions, and concentrations at other nearby stations.

Two results failed DQOs, but were not removed from the dataset based solely on the QC results:

- The reported TP value of 20.4 µg/L for NF2M-5 collected during the ice-cover season was higher than its duplicate (3 µg/L for NF2M-4) and failed the DQO, with an RPD of 146%. The sample was not re-analyzed by the laboratory. Although the TP value seemed rather high based on past AEMPs, there was no additional reason beyond professional judgement to remove it from the dataset. Therefore, it was retained in the dataset and evaluated further in the anomalous screening step, which provided confirmation that this value was anomalous (Attachment B).
- The reported TP value of 9.9 µg-P/L for MF2-1-5 collected during the open-water season was higher than its duplicate (2.4 µg-P/L for MF2-1-4) and failed the DQO with an RPD of 122%. Again, although the TP value seemed high based on past AEMPs, there was no additional reason beyond professional judgement to remove it from the dataset. Therefore, it was retained in the dataset and evaluated further in the anomalous screening step, which provided confirmation that this value was anomalous (Attachment B).

Four other values were considered notable but were retained in the dataset. These values and the rationale for their notability are provided below:

- A nitrate and nitrate + nitrite value of 51 µg-N/L for FFD-1M-5 was reported for the ice-cover season. The corresponding values for the duplicates were non-detect (i.e., <2 µg-N/L). This was the first year this station has been sampled and thus there were no historical data for comparison. Although the RPD is high (192%), these values were not identified as anomalous in the screening step (Attachment B), and the average concentrations for this station were reasonable given the concentrations at nearby stations (see Figures 3-24 and 3-25). Therefore, the results were retained in the dataset for generating plots and statistical analysis.
- The reported TDP values of 5.5 µg-P/L at NF2 bottom depth and 7.1 µg-P/L at NF2 mid depth during the ice-cover season are suspected to be biased high. These values were not considered a QC fail, given that they were still within 5× the DL; however, both values were greater than the corresponding TP values, and presented with high RPDs (i.e., 89% and 67%, respectively). These values were not identified as anomalous values and were retained within the dataset for generating plots and statistical analysis.

A TN value of 475 µg-N/L for FFD-1 was reported for the open-water season. The corresponding values for the other nitrogen species (i.e., TDN, TKN, and DKN) were substantially lower and therefore, this value was likely inaccurate. This value was not identified as anomalous and was retained in the dataset for preparing plots; however, for the extent of effects calculations, the maximum value from the alternate nitrogen species (i.e., TDN, TKN, and DKN) was used instead of the reported TN value. This resulted in the value adjusted from 475 µg-N/L to 150 µg-N/L, which was the reported result for TKN at FFD-1 during the open-water season.

Table C-5 Summary of Duplicate Sample Results for Nutrient Variables, Ice-cover Season, 2020

Variable	Season	Station	Sample Date	DL (µg/L)	Result 1 (µg/L)	Result 2 (µg/L)	Relative Percent Difference (%)	>5 × DL?	QC Fail?
Total Phosphorus (µg-P/L)	IC	FF1-2M	22-Apr-20	2	3.9	2.1	60	N	N
	IC	FF2-2B	29-Apr-20	2	<2	<2	0	N	N
	IC	FF2-2M	29-Apr-20	2	<2	2.4	82	N	N
	IC	FF2-2T	29-Apr-20	2	<2	3.4	109	N	N
	IC	FF2-5B	29-Apr-20	2	<2	<2	0	N	N
	IC	FF2-5M	29-Apr-20	2	<2	<2	0	N	N
	IC	FF2-5T	29-Apr-20	2	3.2	4.7	38	N	N
	IC	FFD-1M	23-Apr-20	2	2.7	3.3	20	N	N
	IC	LDG-48	25-Apr-20	2	2.1	2.2	5	N	N
	IC	MF1-1B	21-Apr-20	2	3.2	<2	105	N	N
	IC	MF1-1M	21-Apr-20	2	2.3	3.1	30	N	N
	IC	MF1-1T	21-Apr-20	2	<2	3.5	111	N	N
	IC	MF1-3B	21-Apr-20	2	<2	2.1	71	N	N
	IC	MF1-3M	21-Apr-20	2	<2	<2	0	N	N
	IC	MF1-3T	21-Apr-20	2	2.3	3	26	N	N
	IC	MF1-5B	22-Apr-20	2	3.7	2.5	39	N	N
	IC	MF1-5M	22-Apr-20	2	<2	2.3	79	N	N
	IC	MF1-5T	22-Apr-20	2	3.2	2.9	10	N	N
	IC	MF2-1B	27-Apr-20	2	2.3	3.2	33	N	N
	IC	MF2-1M	27-Apr-20	2	2.5	3.3	28	N	N
	IC	MF2-1T	27-Apr-20	2	5.8	4.2	32	N	N
	IC	MF2-3B	1-May-20	2	<2	<2	0	N	N
	IC	MF2-3M	1-May-20	2	<2	<2	0	N	N
	IC	MF2-3T	1-May-20	2	<2	<2	0	N	N
	IC	MF3-1B	27-Apr-20	2	3.2	3.5	9	N	N
	IC	MF3-1M	27-Apr-20	2	<2	3.4	109	N	N
	IC	MF3-1T	27-Apr-20	2	2	3.7	60	N	N
	IC	MF3-2B	27-Apr-20	2	<2	<2	0	N	N
	IC	MF3-2M	27-Apr-20	2	<2	<2	0	N	N
	IC	MF3-2T	27-Apr-20	2	<2	2.6	89	N	N
	IC	MF3-3B	25-Apr-20	2	3.6	2.8	25	N	N
	IC	MF3-3M	25-Apr-20	2	2.5	4.1	49	N	N
	IC	MF3-3T	25-Apr-20	2	<2	4	120	N	N
	IC	MF3-4B	26-Apr-20	2	2.5	2.1	17	N	N
	IC	MF3-4M	26-Apr-20	2	<2	2.6	89	N	N
	IC	MF3-4T	26-Apr-20	2	<2	2.3	79	N	N
	IC	MF3-5B	26-Apr-20	2	3.1	3.2	3	N	N
	IC	MF3-5M	26-Apr-20	2	2.9	3.6	22	N	N
	IC	MF3-5T	26-Apr-20	2	<2	2.4	82	N	N
	IC	MF3-6B	26-Apr-20	2	<2	<2	0	N	N
	IC	MF3-6M	26-Apr-20	2	5.2	3.6	36	N	N
	IC	MF3-6M(a)	26-Apr-20	2	<2	3.1	102	N	N
	IC	MF3-6T	26-Apr-20	2	3.1	3.6	15	N	N
	IC	MF3-7B	23-Apr-20	2	<2	2.7	92	N	N
	IC	MF3-7M	23-Apr-20	2	2.8	<2	95	N	N
	IC	MF3-7T	23-Apr-20	2	2.8	<2	95	N	N
	IC	NF1B	28-Apr-20	2	<2	<2	0	N	N
	IC	NF1M	28-Apr-20	2	2.4	<2	82	N	N
	IC	NF1T	28-Apr-20	2	3.7	<2	115	N	N
	IC	NF2B	21-Apr-20	2	4.9	2.3	72	N	N
	IC	NF2M	21-Apr-20	2	3.2	20.4(c)	146	Y	Y
	IC	NF2T	21-Apr-20	2	4.1	2	69	N	N
	IC	NF3B	20-Apr-20	2	3.7	2.6	35	N	N
	IC	NF3M	20-Apr-20	2	<2	<2	0	N	N
	IC	NF3T	20-Apr-20	2	<2	<2	0	N	N
	IC	NF4B	28-Apr-20	2	<2	<2	0	N	N
	IC	NF4M	28-Apr-20	2	2	<2	67	N	N
	IC	NF4M(a)	28-Apr-20	2	<2	2	67	N	N
	IC	NF4T	28-Apr-20	2	<2	2.1	71	N	N
	IC	NF5B	1-May-20	2	<2	<2	0	N	N
	IC	NF5M	1-May-20	2	<2	<2	0	N	N
	IC	NF5T	1-May-20	2	<2	2.3	79	N	N

Table C-5 Summary of Duplicate Sample Results for Nutrient Variables, Ice-cover Season, 2020 (continued)

Variable	Season	Station	Sample Date	DL (µg/L)	Result 1 (µg/L)	Result 2 (µg/L)	Relative Percent Difference (%)	>5 × DL?	QC Fail?
Total Dissolved Phosphorus (µg-P/L)	IC	FF1-2M	22-Apr-20	2	<2	<2	0	N	N
	IC	FF2-2B	29-Apr-20	2	<2	<2	0	N	N
	IC	FF2-2M	29-Apr-20	2	<2	<2	0	N	N
	IC	FF2-2T	29-Apr-20	2	<2	<2	0	N	N
	IC	FF2-5B	29-Apr-20	2	<2	<2	0	N	N
	IC	FF2-5M	29-Apr-20	2	<2	<2	0	N	N
	IC	FF2-5T	29-Apr-20	2	<2	<2	0	N	N
	IC	FFD-1M	23-Apr-20	2	<2	<2	0	N	N
	IC	LDG-48	25-Apr-20	2	<2	3.2	105	N	N
	IC	MF1-1B	21-Apr-20	2	<2	<2	0	N	N
	IC	MF1-1M	21-Apr-20	2	<2	<2	0	N	N
	IC	MF1-1T	21-Apr-20	2	<2	<2	0	N	N
	IC	MF1-3B	21-Apr-20	2	<2	<2	0	N	N
	IC	MF1-3M	21-Apr-20	2	<2	<2	0	N	N
	IC	MF1-3T	21-Apr-20	2	2.4	<2	82	N	N
	IC	MF1-5B	22-Apr-20	2	<2	<2	0	N	N
	IC	MF1-5M	22-Apr-20	2	3.2	2.3	33	N	N
	IC	MF1-5T	22-Apr-20	2	<2	<2	0	N	N
	IC	MF2-1B	27-Apr-20	2	<2	<2	0	N	N
	IC	MF2-1M	27-Apr-20	2	<2	<2	0	N	N
	IC	MF2-1T	27-Apr-20	2	<2	<2	0	N	N
	IC	MF2-3B	01-May-20	2	<2	<2	0	N	N
	IC	MF2-3M	01-May-20	2	<2	<2	0	N	N
	IC	MF2-3T	01-May-20	2	<2	<2	0	N	N
	IC	MF3-1B	27-Apr-20	2	<2	<2	0	N	N
	IC	MF3-1M	27-Apr-20	2	<2	<2	0	N	N
	IC	MF3-1T	27-Apr-20	2	<2	<2	0	N	N
	IC	MF3-2B	27-Apr-20	2	<2	<2	0	N	N
	IC	MF3-2M	27-Apr-20	2	<2	<2	0	N	N
	IC	MF3-2T	27-Apr-20	2	<2	<2	0	N	N
	IC	MF3-3B	25-Apr-20	2	<2	2.3	79	N	N
	IC	MF3-3M	25-Apr-20	2	<2	<2	0	N	N
	IC	MF3-3T	25-Apr-20	2	<2	<2	0	N	N
	IC	MF3-4B	26-Apr-20	2	<2	<2	0	N	N
	IC	MF3-4M	26-Apr-20	2	<2	<2	0	N	N
	IC	MF3-4T	26-Apr-20	2	<2	<2	0	N	N
	IC	MF3-5B	26-Apr-20	2	<2	<2	0	N	N
	IC	MF3-5M	26-Apr-20	2	<2	<2	0	N	N
	IC	MF3-5T	26-Apr-20	2	<2	<2	0	N	N
	IC	MF3-6B	26-Apr-20	2	<2	<2	0	N	N
	IC	MF3-6M	26-Apr-20	2	<2	<2	0	N	N
	IC	MF3-6M(a)	26-Apr-20	2	<2	<2	0	N	N
	IC	MF3-6T	26-Apr-20	2	<2	<2	0	N	N
	IC	MF3-7B	23-Apr-20	2	<2	<2	0	N	N
	IC	MF3-7M	23-Apr-20	2	<2	<2	0	N	N
	IC	MF3-7T	23-Apr-20	2	<2	<2	0	N	N
	IC	NF1B	28-Apr-20	2	<2	<2	0	N	N
	IC	NF1M	28-Apr-20	2	<2	<2	0	N	N
	IC	NF1T	28-Apr-20	2	<2	<2	0	N	N
	IC	NF2B	21-Apr-20	2	4.9	6	20	N	N
	IC	NF2M	21-Apr-20	2	6.4	7.7	18	N	N
	IC	NF2T	21-Apr-20	2	<2	<2	0	N	N
	IC	NF3B	20-Apr-20	2	<2	<2	0	N	N
	IC	NF3M	20-Apr-20	2	<2	<2	0	N	N
	IC	NF3T	20-Apr-20	2	<2	<2	0	N	N
	IC	NF4B	28-Apr-20	2	<2	<2	0	N	N
	IC	NF4M	28-Apr-20	2	<2	<2	0	N	N
	IC	NF4M(a)	28-Apr-20	2	<2	<2	0	N	N
	IC	NF4T	28-Apr-20	2	<2	<2	0	N	N
	IC	NF5B	01-May-20	2	<2	<2	0	N	N
	IC	NF5M	01-May-20	2	<2	<2	0	N	N
	IC	NF5T	01-May-20	2	2.1	<2	71	N	N

Table C-5 Summary of Duplicate Sample Results for Nutrient Variables, Ice-cover Season, 2020 (continued)

Variable	Season	Station	Sample Date	DL (µg/L)	Result 1 (µg/L)	Result 2 (µg/L)	Relative Percent Difference (%)	>5 × DL?	QC Fail?
Soluble Reactive Phosphorus (µg-P/L)	IC	FF1-2M	22-Apr-20	1	<1	<1	0	N	N
	IC	FF2-2B	29-Apr-20	1	<1	<1	0	N	N
	IC	FF2-2M	29-Apr-20	1	1.3	<1	89	N	N
	IC	FF2-2T	29-Apr-20	1	3.6	<1	151	N	N
	IC	FF2-5B	29-Apr-20	1	<1	<1	0	N	N
	IC	FF2-5M	29-Apr-20	1	<1	<1	0	N	N
	IC	FF2-5T	29-Apr-20	1	<1	<1	0	N	N
	IC	FFD-1M	23-Apr-20	1	<1	<1	0	N	N
	IC	LDG-48	25-Apr-20	1	<1	<1	0	N	N
	IC	MF1-1B	21-Apr-20	1	<1	<1	0	N	N
	IC	MF1-1M	21-Apr-20	1	<1	<1	0	N	N
	IC	MF1-1T	21-Apr-20	1	<1	<1	0	N	N
	IC	MF1-3B	21-Apr-20	1	<1	<1	0	N	N
	IC	MF1-3M	21-Apr-20	1	<1	<1	0	N	N
	IC	MF1-3T	21-Apr-20	1	<1	<1	0	N	N
	IC	MF1-5B	22-Apr-20	1	<1	<1	0	N	N
	IC	MF1-5M	22-Apr-20	1	<1	<1	0	N	N
	IC	MF1-5T	22-Apr-20	1	<1	<1	0	N	N
	IC	MF2-1B	27-Apr-20	1	1.3	<1	89	N	N
	IC	MF2-1M	27-Apr-20	1	<1	<1	0	N	N
	IC	MF2-1T	27-Apr-20	1	<1	<1	0	N	N
	IC	MF2-3B	01-May-20	1	<1	<1	0	N	N
	IC	MF2-3M	01-May-20	1	<1	<1	0	N	N
	IC	MF2-3T	01-May-20	1	<1	<1	0	N	N
	IC	MF3-1B	27-Apr-20	1	<1	<1	0	N	N
	IC	MF3-1M	27-Apr-20	1	4	<1	156	N	N
	IC	MF3-1T	27-Apr-20	1	<1	<1	0	N	N
	IC	MF3-2B	27-Apr-20	1	<1	<1	0	N	N
	IC	MF3-2M	27-Apr-20	1	<1	<1	0	N	N
	IC	MF3-2T	27-Apr-20	1	<1	<1	0	N	N
	IC	MF3-3B	25-Apr-20	1	<1	<1	0	N	N
	IC	MF3-3M	25-Apr-20	1	1.9	<1	117	N	N
	IC	MF3-3T	25-Apr-20	1	<1	<1	0	N	N
	IC	MF3-4B	26-Apr-20	1	<1	<1	0	N	N
	IC	MF3-4M	26-Apr-20	1	<1	<1	0	N	N
	IC	MF3-4T	26-Apr-20	1	<1	<1	0	N	N
	IC	MF3-5B	26-Apr-20	1	<1	<1	0	N	N
	IC	MF3-5M	26-Apr-20	1	<1	<1	0	N	N
	IC	MF3-5T	26-Apr-20	1	<1	<1	0	N	N
	IC	MF3-6B	26-Apr-20	1	<1	<1	0	N	N
	IC	MF3-6M	26-Apr-20	1	1	1.4	33	N	N
	IC	MF3-6M(a)	26-Apr-20	1	1	1	0	N	N
	IC	MF3-6T	26-Apr-20	1	<1	<1	0	N	N
	IC	MF3-7B	23-Apr-20	1	<1	<1	0	N	N
	IC	MF3-7M	23-Apr-20	1	<1	<1	0	N	N
	IC	MF3-7T	23-Apr-20	1	1.4	<1	95	N	N
	IC	NF1B	28-Apr-20	1	1.2	<1	82	N	N
	IC	NF1M	28-Apr-20	1	<1	2.2	126	N	N
	IC	NF1T	28-Apr-20	1	<1	<1	0	N	N
	IC	NF2B	21-Apr-20	1	1.2	1.5	22	N	N
	IC	NF2M	21-Apr-20	1	<1	<1	0	N	N
	IC	NF2T	21-Apr-20	1	4	<1	156	N	N
	IC	NF3B	20-Apr-20	1	<1	1.5	100	N	N
	IC	NF3M	20-Apr-20	1	<1	<1	0	N	N
	IC	NF3T	20-Apr-20	1	<1	<1	0	N	N
	IC	NF4B	28-Apr-20	1	1.3	<1	89	N	N
	IC	NF4M	28-Apr-20	1	1	1.3	26	N	N
	IC	NF4M(a)	28-Apr-20	1	1	1	0	N	N
	IC	NF4T	28-Apr-20	1	1.6	<1	105	N	N
	IC	NF5B	01-May-20	1	<1	1.7	109	N	N
	IC	NF5M	01-May-20	1	<1	1.3	89	N	N
	IC	NF5T	01-May-20	1	<1	1.3	89	N	N

Table C-5 Summary of Duplicate Sample Results for Nutrient Variables, Ice-cover Season, 2020 (continued)

Variable	Season	Station	Sample Date	DL (µg/L)	Result 1 (µg/L)	Result 2 (µg/L)	Relative Percent Difference (%)	>5 × DL?	QC Fail?
Total Nitrogen (µg-N/L)	IC	FF1-2M	22-Apr-20	20	150	160	7	Y	N
	IC	FF2-2B	29-Apr-20	20	270	300	11	Y	N
	IC	FF2-2M	29-Apr-20	20	280	240	15	Y	N
	IC	FF2-2T	29-Apr-20	20	310	300	3	Y	N
	IC	FF2-5B	29-Apr-20	20	270	350	26	Y	N
	IC	FF2-5M	29-Apr-20	20	270	310	14	Y	N
	IC	FF2-5T	29-Apr-20	20	270	330	20	Y	N
	IC	FFD-1M	23-Apr-20	20	200	200	0	Y	N
	IC	LDG-48	25-Apr-20	20	210	220	5	Y	N
	IC	MF1-1B	21-Apr-20	20	310	300	3	Y	N
	IC	MF1-1M	21-Apr-20	20	250	250	0	Y	N
	IC	MF1-1T	21-Apr-20	20	270	250	8	Y	N
	IC	MF1-3B	21-Apr-20	20	270	240	12	Y	N
	IC	MF1-3M	21-Apr-20	20	220	230	4	Y	N
	IC	MF1-3T	21-Apr-20	20	240	220	9	Y	N
	IC	MF1-5B	22-Apr-20	20	270	230	16	Y	N
	IC	MF1-5M	22-Apr-20	20	200	170	16	Y	N
	IC	MF1-5T	22-Apr-20	20	180	150	18	Y	N
	IC	MF2-1B	27-Apr-20	20	350	350	0	Y	N
	IC	MF2-1M	27-Apr-20	20	290	250	15	Y	N
	IC	MF2-1T	27-Apr-20	20	240	240	0	Y	N
	IC	MF2-3B	01-May-20	20	280	290	4	Y	N
	IC	MF2-3M	01-May-20	20	230	240	4	Y	N
	IC	MF2-3T	01-May-20	20	290	330	13	Y	N
	IC	MF3-1B	27-Apr-20	20	280	260	7	Y	N
	IC	MF3-1M	27-Apr-20	20	230	220	4	Y	N
	IC	MF3-1T	27-Apr-20	20	190	200	5	Y	N
	IC	MF3-2B	27-Apr-20	20	210	220	5	Y	N
	IC	MF3-2M	27-Apr-20	20	220	230	4	Y	N
	IC	MF3-2T	27-Apr-20	20	180	170	6	Y	N
	IC	MF3-3B	25-Apr-20	20	270	300	11	Y	N
	IC	MF3-3M	25-Apr-20	20	270	280	4	Y	N
	IC	MF3-3T	25-Apr-20	20	160	170	6	Y	N
	IC	MF3-4B	26-Apr-20	20	250	210	17	Y	N
	IC	MF3-4M	26-Apr-20	20	250	220	13	Y	N
	IC	MF3-4T	26-Apr-20	20	190	180	5	Y	N
	IC	MF3-5B	26-Apr-20	20	220	200	10	Y	N
	IC	MF3-5M	26-Apr-20	20	180	180	0	Y	N
	IC	MF3-5T	26-Apr-20	20	160	180	12	Y	N
	IC	MF3-6B	26-Apr-20	20	170	180	6	Y	N
	IC	MF3-6M	26-Apr-20	20	170	200	16	Y	N
	IC	MF3-6M(a)	26-Apr-20	20	160	180	12	Y	N
	IC	MF3-6T	26-Apr-20	20	170	190	11	Y	N
	IC	MF3-7B	23-Apr-20	20	160	200	22	Y	N
	IC	MF3-7M	23-Apr-20	20	170	170	0	Y	N
	IC	MF3-7T	23-Apr-20	20	170	<20(b)	178	Y	Y
	IC	NF1B	28-Apr-20	20	450	410	9	Y	N
	IC	NF1M	28-Apr-20	20	330	360	9	Y	N
	IC	NF1T	28-Apr-20	20	310	280	10	Y	N
	IC	NF2B	21-Apr-20	20	360	330	9	Y	N
	IC	NF2M	21-Apr-20	20	340	340	0	Y	N
	IC	NF2T	21-Apr-20	20	200	210	5	Y	N
	IC	NF3B	20-Apr-20	20	360	350	3	Y	N
	IC	NF3M	20-Apr-20	20	270	280	4	Y	N
	IC	NF3T	20-Apr-20	20	240	220	9	Y	N
	IC	NF4B	28-Apr-20	20	350	440	23	Y	N
	IC	NF4M	28-Apr-20	20	350	350	0	Y	N
	IC	NF4M(a)	28-Apr-20	20	350	340	3	Y	N
	IC	NF4T	28-Apr-20	20	270	300	11	Y	N
	IC	NF5B	01-May-20	20	380	410	8	Y	N
	IC	NF5M	01-May-20	20	310	320	3	Y	N
	IC	NF5T	01-May-20	20	250	240	4	Y	N

Table C-5 Summary of Duplicate Sample Results for Nutrient Variables, Ice-cover Season, 2020 (continued)

Variable	Season	Station	Sample Date	DL (µg/L)	Result 1 (µg/L)	Result 2 (µg/L)	Relative Percent Difference (%)	>5 × DL?	QC Fail?
Total Dissolved Nitrogen (µg-N/L)	IC	FF1-2M	22-Apr-20	20	190	190	0	Y	N
	IC	FF2-2B	29-Apr-20	20	250	270	8	Y	N
	IC	FF2-2M	29-Apr-20	20	220	220	0	Y	N
	IC	FF2-2T	29-Apr-20	20	300	290	3	Y	N
	IC	FF2-5B	29-Apr-20	20	270	260	4	Y	N
	IC	FF2-5M	29-Apr-20	20	230	210	9	Y	N
	IC	FF2-5T	29-Apr-20	20	250	250	0	Y	N
	IC	FFD-1M	23-Apr-20	20	200	220	10	Y	N
	IC	LDG-48	25-Apr-20	20	200	200	0	Y	N
	IC	MF1-1B	21-Apr-20	20	260	250	4	Y	N
	IC	MF1-1M	21-Apr-20	20	280	210	29	Y	N
	IC	MF1-1T	21-Apr-20	20	210	230	9	Y	N
	IC	MF1-3B	21-Apr-20	20	230	230	0	Y	N
	IC	MF1-3M	21-Apr-20	20	200	200	0	Y	N
	IC	MF1-3T	21-Apr-20	20	180	180	0	Y	N
	IC	MF1-5B	22-Apr-20	20	250	260	4	Y	N
	IC	MF1-5M	22-Apr-20	20	230	230	0	Y	N
	IC	MF1-5T	22-Apr-20	20	190	250	27	Y	N
	IC	MF2-1B	27-Apr-20	20	370	380	3	Y	N
	IC	MF2-1M	27-Apr-20	20	320	290	10	Y	N
	IC	MF2-1T	27-Apr-20	20	250	250	0	Y	N
	IC	MF2-3B	01-May-20	20	230	220	4	Y	N
	IC	MF2-3M	01-May-20	20	200	220	10	Y	N
	IC	MF2-3T	01-May-20	20	250	230	8	Y	N
	IC	MF3-1B	27-Apr-20	20	320	310	3	Y	N
	IC	MF3-1M	27-Apr-20	20	270	240	12	Y	N
	IC	MF3-1T	27-Apr-20	20	240	250	4	Y	N
	IC	MF3-2B	27-Apr-20	20	210	230	9	Y	N
	IC	MF3-2M	27-Apr-20	20	220	220	0	Y	N
	IC	MF3-2T	27-Apr-20	20	180	160	12	Y	N
	IC	MF3-3B	25-Apr-20	20	200	190	5	Y	N
	IC	MF3-3M	25-Apr-20	20	180	180	0	Y	N
	IC	MF3-3T	25-Apr-20	20	210	200	5	Y	N
	IC	MF3-4B	26-Apr-20	20	200	180	11	Y	N
	IC	MF3-4M	26-Apr-20	20	190	200	5	Y	N
	IC	MF3-4T	26-Apr-20	20	160	170	6	Y	N
	IC	MF3-5B	26-Apr-20	20	180	220	20	Y	N
	IC	MF3-5M	26-Apr-20	20	150	180	18	Y	N
	IC	MF3-5T	26-Apr-20	20	160	150	7	Y	N
	IC	MF3-6B	26-Apr-20	20	150	150	0	Y	N
	IC	MF3-6M	26-Apr-20	20	140	140	0	Y	N
	IC	MF3-6M(a)	26-Apr-20	20	150	140	7	Y	N
	IC	MF3-6T	26-Apr-20	20	150	150	0	Y	N
	IC	MF3-7B	23-Apr-20	20	170	160	6	Y	N
	IC	MF3-7M	23-Apr-20	20	150	140	7	Y	N
	IC	MF3-7T	23-Apr-20	20	140	130	7	Y	N
	IC	NF1B	28-Apr-20	20	390	380	3	Y	N
	IC	NF1M	28-Apr-20	20	290	310	7	Y	N
	IC	NF1T	28-Apr-20	20	240	230	4	Y	N
	IC	NF2B	21-Apr-20	20	300	300	0	Y	N
	IC	NF2M	21-Apr-20	20	290	280	4	Y	N
	IC	NF2T	21-Apr-20	20	160	170	6	Y	N
	IC	NF3B	20-Apr-20	20	300	310	3	Y	N
	IC	NF3M	20-Apr-20	20	250	240	4	Y	N
	IC	NF3T	20-Apr-20	20	190	180	5	Y	N
	IC	NF4B	28-Apr-20	20	370	390	5	Y	N
	IC	NF4M	28-Apr-20	20	300	290	3	Y	N
	IC	NF4M(a)	28-Apr-20	20	300	320	7	Y	N
	IC	NF4T	28-Apr-20	20	240	240	0	Y	N
	IC	NF5B	01-May-20	20	310	340	9	Y	N
	IC	NF5M	01-May-20	20	290	280	4	Y	N
	IC	NF5T	01-May-20	20	230	230	0	Y	N

Table C-5 Summary of Duplicate Sample Results for Nutrient Variables, Ice-cover Season, 2020 (continued)

Variable	Season	Station	Sample Date	DL (µg/L)	Result 1 (µg/L)	Result 2 (µg/L)	Relative Percent Difference (%)	>5 × DL?	QC Fail?
Total Ammonia (µg-N/L) - ALS	IC	FF1-2M	22-Apr-20	5	16.4	16.8	2	N	N
	IC	FF2-2B	29-Apr-20	5	9.5	8.0	17	N	N
	IC	FF2-2M	29-Apr-20	5	15.2	29.8	65	Y	Y
	IC	FF2-2T	29-Apr-20	5	34.6	33.6	3	Y	N
	IC	FF2-5B	29-Apr-20	5	18.1	40.4	76	Y	Y
	IC	FF2-5M	29-Apr-20	5	11.2	35.1	103	Y	Y
	IC	FF2-5T	29-Apr-20	5	51.4	22.7	78	Y	Y
	IC	FFD-1M	23-Apr-20	5	16.4	17.2	5	N	N
	IC	LDG-48	25-Apr-20	5	13.8	18.5	29	N	N
	IC	MF1-1B	21-Apr-20	5	15.5	18.2	16	N	N
	IC	MF1-1M	21-Apr-20	5	22.9	24.5	7	N	N
	IC	MF1-1T	21-Apr-20	5	34.6	28.6	19	Y	N
	IC	MF1-3B	21-Apr-20	5	33	15.7	71	Y	Y
	IC	MF1-3M	21-Apr-20	5	18.4	19.2	4	N	N
	IC	MF1-3T	21-Apr-20	5	24.3	25	3	N	N
	IC	MF1-5B	22-Apr-20	5	12.6	28.5	77	Y	Y
	IC	MF1-5M	22-Apr-20	5	37.4	14.9	86	Y	Y
	IC	MF1-5T	22-Apr-20	5	15.3	14.7	4	N	N
	IC	MF2-1B	27-Apr-20	5	32.7	21	44	Y	Y
	IC	MF2-1M	27-Apr-20	5	14	14.9	6	N	N
	IC	MF2-1T	27-Apr-20	5	22.2	35.5	46	Y	Y
	IC	MF2-3B	01-May-20	5	7	6.3	11	N	N
	IC	MF2-3M	01-May-20	5	6.5	20.9	105	N	N
	IC	MF2-3T	01-May-20	5	24.9	26.2	5	Y	N
	IC	MF3-1B	27-Apr-20	5	33	21.5	42	Y	Y
	IC	MF3-1M	27-Apr-20	5	31.2	20.4	42	Y	Y
	IC	MF3-1M(a)	27-Apr-20	5	18.7	22.2	17	N	N
	IC	MF3-1T	27-Apr-20	5	19.1	19.5	2	N	N
	IC	MF3-2B	27-Apr-20	5	18.4	21.2	14	N	N
	IC	MF3-2M	27-Apr-20	5	16.1	27	51	Y	Y
	IC	MF3-2T	27-Apr-20	5	19.7	20.6	5	N	N
	IC	MF3-3B	25-Apr-20	5	15.4	13	17	N	N
	IC	MF3-3M	25-Apr-20	5	18.8	17.2	9	N	N
	IC	MF3-3T	25-Apr-20	5	19.5	21	7	N	N
	IC	MF3-4B	26-Apr-20	5	18.5	22	17	N	N
	IC	MF3-4M	26-Apr-20	5	15.7	15.1	4	N	N
	IC	MF3-4T	26-Apr-20	5	15.8	18.4	15	N	N
	IC	MF3-5B	26-Apr-20	5	16.4	19.7	18	N	N
	IC	MF3-5M	26-Apr-20	5	18.7	32.4	54	Y	Y
	IC	MF3-5T	26-Apr-20	5	16.1	15.9	1	N	N
	IC	MF3-6B	26-Apr-20	5	17.3	17.2	1	N	N
	IC	MF3-6M	26-Apr-20	5	17.2	17.7	3	N	N
	IC	MF3-6M(a)	26-Apr-20	5	19.8	16.7	17	N	N
	IC	MF3-6T	26-Apr-20	5	17.2	15.8	9	N	N
	IC	MF3-7B	23-Apr-20	5	18	21.5	18	N	N
	IC	MF3-7M	23-Apr-20	5	19.8	18.4	7	N	N
	IC	MF3-7T	23-Apr-20	5	14.6	30.3	70	Y	Y
	IC	NF1B	28-Apr-20	5	31.4	33.6	7	Y	N
	IC	NF1M	28-Apr-20	5	26	31.5	19	Y	N
	IC	NF1T	28-Apr-20	5	43.7	23.1	62	Y	Y
	IC	NF2B	21-Apr-20	5	39.8	36.7	8	Y	N
	IC	NF2M	21-Apr-20	5	56.6	34.5	49	Y	Y
	IC	NF2T	21-Apr-20	5	19.9	20.8	4	N	N
	IC	NF3B	20-Apr-20	5	34.9	40.8	16	Y	N
	IC	NF3M	20-Apr-20	5	28.5	23.2	21	Y	N
	IC	NF3T	20-Apr-20	5	20.4	20.6	1	N	N
	IC	NF4B	28-Apr-20	5	29.2	28.5	2	Y	N
	IC	NF4M	28-Apr-20	5	19.6	18.2	7	N	N
	IC	NF4M(a)	28-Apr-20	5	26.8	33.1	21	Y	N
	IC	NF4T	28-Apr-20	5	24.8	22.2	11	N	N
	IC	NF5B	01-May-20	5	27.8	41.5	40	Y	N
	IC	NF5M	01-May-20	5	19.1	20.7	8	N	N
	IC	NF5T	01-May-20	5	25.5	26	2	Y	N

Table C-5 Summary of Duplicate Sample Results for Nutrient Variables, Ice-cover Season, 2020 (continued)

Variable	Season	Station	Sample Date	DL (µg/L)	Result 1 (µg/L)	Result 2 (µg/L)	Relative Percent Difference (%)	>5 × DL?	QC Fail?
Total Ammonia (µg-N/L) - BV Labs	IC	FF1-2M	22-Apr-20	5	110	76	37	Y	N
	IC	FF2-2B	29-Apr-20	5	44	36	20	Y	N
	IC	FF2-2M	29-Apr-20	5	65	36	57	Y	Y
	IC	FF2-2T	29-Apr-20	5	53	41	26	Y	N
	IC	FF2-5B	29-Apr-20	5	290	29	164	Y	Y
	IC	FF2-5M	29-Apr-20	5	200	32	145	Y	Y
	IC	FF2-5T	29-Apr-20	5	36	17	72	Y	Y
	IC	FFD-1M	23-Apr-20	5	66	90	31	Y	N
	IC	LDG-48	25-Apr-20	5	34	120	112	Y	Y
	IC	MF1-1B	21-Apr-20	5	30	28	7	Y	N
	IC	MF1-1M	21-Apr-20	5	47	39	19	Y	N
	IC	MF1-1T	21-Apr-20	5	37	53	36	Y	N
	IC	MF1-3B	21-Apr-20	5	38	26	38	Y	N
	IC	MF1-3M	21-Apr-20	5	130	38	110	Y	Y
	IC	MF1-3T	21-Apr-20	5	250	45	139	Y	Y
	IC	MF1-5B	22-Apr-20	5	40	92	79	Y	Y
	IC	MF1-5M	22-Apr-20	5	73	37	66	Y	Y
	IC	MF1-5T	22-Apr-20	5	47	31	41	Y	Y
	IC	MF2-1B	27-Apr-20	5	64	26	84	Y	Y
	IC	MF2-1M	27-Apr-20	5	19	45	81	Y	Y
	IC	MF2-1T	27-Apr-20	5	210	280	29	Y	N
	IC	MF2-3B	01-May-20	5	28	30	7	Y	N
	IC	MF2-3M	01-May-20	5	88	120	31	Y	N
	IC	MF2-3T	01-May-20	5	60	47	24	Y	N
	IC	MF3-1B	27-Apr-20	5	31	28	10	Y	N
	IC	MF3-1M	27-Apr-20	5	81	21	118	Y	Y
	IC	MF3-1M(a)	27-Apr-20	5	52	45	14	Y	N
	IC	MF3-1T	27-Apr-20	5	50	60	18	Y	N
	IC	MF3-2B	27-Apr-20	5	13	39	100	Y	Y
	IC	MF3-2M	27-Apr-20	5	16	79	133	Y	Y
	IC	MF3-2T	27-Apr-20	5	35	41	16	Y	N
	IC	MF3-3B	25-Apr-20	5	230	260	12	Y	N
	IC	MF3-3M	25-Apr-20	5	41	59	36	Y	N
	IC	MF3-3T	25-Apr-20	5	43	78	58	Y	Y
	IC	MF3-4B	26-Apr-20	5	48	54	12	Y	N
	IC	MF3-4M	26-Apr-20	5	27	53	65	Y	Y
	IC	MF3-4T	26-Apr-20	5	36	18	67	Y	Y
	IC	MF3-5B	26-Apr-20	5	11	42	117	Y	Y
	IC	MF3-5M	26-Apr-20	5	23	27	16	Y	N
	IC	MF3-5T	26-Apr-20	5	20	59	99	Y	Y
	IC	MF3-6B	26-Apr-20	5	24	<5	305	N	N
	IC	MF3-6M	26-Apr-20	5	22	17	26	N	N
	IC	MF3-6M(a)	26-Apr-20	5	35	140	120	Y	Y
	IC	MF3-6T	26-Apr-20	5	18	32	56	Y	Y
	IC	MF3-7B	23-Apr-20	5	110	52	72	Y	Y
	IC	MF3-7M	23-Apr-20	5	48	60	22	Y	N
	IC	MF3-7T	23-Apr-20	5	72	21	110	Y	Y
	IC	NF1B	28-Apr-20	5	100	250	86	Y	Y
	IC	NF1M	28-Apr-20	5	38	330	159	Y	Y
	IC	NF1T	28-Apr-20	5	29	160	139	Y	Y
	IC	NF2B	21-Apr-20	5	51	54	6	Y	N
	IC	NF2M	21-Apr-20	5	250	62	121	Y	Y
	IC	NF2T	21-Apr-20	5	27	26	4	Y	N
	IC	NF3B	20-Apr-20	5	63	95	41	Y	Y
	IC	NF3M	20-Apr-20	5	36	31	15	Y	N
	IC	NF3T	20-Apr-20	5	57	40	35	Y	N
	IC	NF4B	28-Apr-20	5	79	68	15	Y	N
	IC	NF4M	28-Apr-20	5	180	190	5	Y	N
	IC	NF4M(a)	28-Apr-20	5	24	40	50	Y	Y
	IC	NF4T	28-Apr-20	5	37	210	140	Y	Y
	IC	NF5B	01-May-20	5	78	83	6	Y	N
	IC	NF5M	01-May-20	5	35	35	0	Y	N
	IC	NF5T	01-May-20	5	38	30	24	Y	N

Table C-5 Summary of Duplicate Sample Results for Nutrient Variables, Ice-cover Season, 2020 (continued)

Variable	Season	Station	Sample Date	DL (µg/L)	Result 1 (µg/L)	Result 2 (µg/L)	Relative Percent Difference (%)	>5 × DL?	QC Fail?
Nitrate (µg-N/L)	IC	FF1-2M	22-Apr-20	2	<2	3.3	107	N	N
	IC	FF2-2B	29-Apr-20	2	81	81	0	Y	N
	IC	FF2-2M	29-Apr-20	2	59	60	2	Y	N
	IC	FF2-2T	29-Apr-20	2	32	30	7	Y	N
	IC	FF2-5B	29-Apr-20	2	50	75	40	Y	N
	IC	FF2-5M	29-Apr-20	2	59	58	2	Y	N
	IC	FF2-5T	29-Apr-20	2	26	26	0	Y	N
	IC	FFD-1M	23-Apr-20	2	<2	51	192	Y	Y
	IC	LDG-48	25-Apr-20	2	<2	<2	0	N	N
	IC	MF1-1B	21-Apr-20	2	120	100	18	Y	N
	IC	MF1-1M	21-Apr-20	2	63	61	3	Y	N
	IC	MF1-1T	21-Apr-20	2	36	37	3	Y	N
	IC	MF1-3B	21-Apr-20	2	92	91	1	Y	N
	IC	MF1-3M	21-Apr-20	2	69	69	0	Y	N
	IC	MF1-3T	21-Apr-20	2	32	33	3	Y	N
	IC	MF1-5B	22-Apr-20	2	65	66	2	Y	N
	IC	MF1-5M	22-Apr-20	2	15	17	13	Y	N
	IC	MF1-5T	22-Apr-20	2	<2	<2	0	N	N
	IC	MF2-1B	27-Apr-20	2	140	160	13	Y	N
	IC	MF2-1M	27-Apr-20	2	99	85	15	Y	N
	IC	MF2-1T	27-Apr-20	2	16	15	7	Y	N
	IC	MF2-3B	01-May-20	2	71	75	6	Y	N
	IC	MF2-3M	01-May-20	2	52	47	10	Y	N
	IC	MF2-3T	01-May-20	2	33	34	3	Y	N
	IC	MF3-1B	27-Apr-20	2	98	87	12	Y	N
	IC	MF3-1M	27-Apr-20	2	37	52	34	Y	N
	IC	MF3-1T	27-Apr-20	2	11	18	48	Y	Y
	IC	MF3-2B	27-Apr-20	2	60	61	2	Y	N
	IC	MF3-2M	27-Apr-20	2	50	50	0	Y	N
	IC	MF3-2T	27-Apr-20	2	7.7	5.7	30	N	N
	IC	MF3-3B	25-Apr-20	2	48	47	2	Y	N
	IC	MF3-3M	25-Apr-20	2	42	41	2	Y	N
	IC	MF3-3T	25-Apr-20	2	2.2	2.5	13	N	N
	IC	MF3-4B	26-Apr-20	2	52	47	10	Y	N
	IC	MF3-4M	26-Apr-20	2	36	35	3	Y	N
	IC	MF3-4T	26-Apr-20	2	3.8	3.5	8	N	N
	IC	MF3-5B	26-Apr-20	2	41	45	9	Y	N
	IC	MF3-5M	26-Apr-20	2	16	12	29	Y	N
	IC	MF3-5T	26-Apr-20	2	<2	<2	0	N	N
	IC	MF3-6B	26-Apr-20	2	9	15	50	Y	Y
	IC	MF3-6M	26-Apr-20	2	4.6	5.9	25	N	N
	IC	MF3-6M(a)	26-Apr-20	2	5.2	5.9	13	N	N
	IC	MF3-6T	26-Apr-20	2	<2	2.1	71	N	N
	IC	MF3-7B	23-Apr-20	2	16	17	6	Y	N
	IC	MF3-7M	23-Apr-20	2	4.6	4.1	12	N	N
	IC	MF3-7T	23-Apr-20	2	<2	<2	0	N	N
	IC	NF1B	28-Apr-20	2	170	170	0	Y	N
	IC	NF1M	28-Apr-20	2	130	130	0	Y	N
	IC	NF1T	28-Apr-20	2	42	41	2	Y	N
	IC	NF2B	21-Apr-20	2	140	140	0	Y	N
	IC	NF2M	21-Apr-20	2	120	130	8	Y	N
	IC	NF2T	21-Apr-20	2	28	30	7	Y	N
	IC	NF3B	20-Apr-20	2	140	140	0	Y	N
	IC	NF3M	20-Apr-20	2	100	92	8	Y	N
	IC	NF3T	20-Apr-20	2	32	31	3	Y	N
	IC	NF4B	28-Apr-20	2	190	180	5	Y	N
	IC	NF4M	28-Apr-20	2	120	120	0	Y	N
	IC	NF4M(a)	28-Apr-20	2	120	120	0	Y	N
	IC	NF4T	28-Apr-20	2	41	41	0	Y	N
	IC	NF5B	01-May-20	2	160	160	0	Y	N
	IC	NF5M	01-May-20	2	120	110	9	Y	N
	IC	NF5T	01-May-20	2	34	36	6	Y	N

Table C-5 Summary of Duplicate Sample Results for Nutrient Variables, Ice-cover Season, 2020 (continued)

Variable	Season	Station	Sample Date	DL (µg/L)	Result 1 (µg/L)	Result 2 (µg/L)	Relative Percent Difference (%)	>5 × DL?	QC Fail?
Nitrite (µg-N/L)	IC	FF1-2M	22-Apr-20	1	1.5	<1	100	N	N
	IC	FF2-2B	29-Apr-20	1	5.7	5.3	7	Y	N
	IC	FF2-2M	29-Apr-20	1	<1	<1	0	N	N
	IC	FF2-2T	29-Apr-20	1	5.9	6.3	7	Y	N
	IC	FF2-5B	29-Apr-20	1	3	4	29	N	N
	IC	FF2-5M	29-Apr-20	1	3.1	2.6	18	N	N
	IC	FF2-5T	29-Apr-20	1	2.7	2.4	12	N	N
	IC	FFD-1M	23-Apr-20	1	<1	<1	0	N	N
	IC	LDG-48	25-Apr-20	1	<1	<1	0	N	N
	IC	MF1-1B	21-Apr-20	1	1.4	1.5	7	N	N
	IC	MF1-1M	21-Apr-20	1	1.4	1.4	0	N	N
	IC	MF1-1T	21-Apr-20	1	<1	<1	0	N	N
	IC	MF1-3B	21-Apr-20	1	2.5	3.2	25	N	N
	IC	MF1-3M	21-Apr-20	1	1.7	2	16	N	N
	IC	MF1-3T	21-Apr-20	1	1.6	1.2	29	N	N
	IC	MF1-5B	22-Apr-20	1	<1	<1	0	N	N
	IC	MF1-5M	22-Apr-20	1	4.2	5.4	25	Y	N
	IC	MF1-5T	22-Apr-20	1	<1	<1	0	N	N
	IC	MF2-1B	27-Apr-20	1	1.2	<1	82	N	N
	IC	MF2-1M	27-Apr-20	1	<1	<1	0	N	N
	IC	MF2-1T	27-Apr-20	1	<1	<1	0	N	N
	IC	MF2-3B	01-May-20	1	<1	<1	0	N	N
	IC	MF2-3M	01-May-20	1	<1	<1	0	N	N
	IC	MF2-3T	01-May-20	1	<1	<1	0	N	N
	IC	MF3-1B	27-Apr-20	1	1.4	1.1	24	N	N
	IC	MF3-1M	27-Apr-20	1	<1	2.8	139	N	N
	IC	MF3-1T	27-Apr-20	1	<1	2	120	N	N
	IC	MF3-2B	27-Apr-20	1	2.9	3.3	13	N	N
	IC	MF3-2M	27-Apr-20	1	3.5	1.8	64	N	N
	IC	MF3-2T	27-Apr-20	1	2.9	2.7	7	N	N
	IC	MF3-3B	25-Apr-20	1	1.8	2	11	N	N
	IC	MF3-3M	25-Apr-20	1	1.9	2.1	10	N	N
	IC	MF3-3T	25-Apr-20	1	4	2.2	58	N	N
	IC	MF3-4B	26-Apr-20	1	3.1	1.8	53	N	N
	IC	MF3-4M	26-Apr-20	1	2.6	2.4	8	N	N
	IC	MF3-4T	26-Apr-20	1	2	2	0	N	N
	IC	MF3-5B	26-Apr-20	1	2.9	3.3	13	N	N
	IC	MF3-5M	26-Apr-20	1	<1	<1	0	N	N
	IC	MF3-5T	26-Apr-20	1	1.5	2.9	64	N	N
	IC	MF3-6B	26-Apr-20	1	4.2	3.3	24	N	N
	IC	MF3-6M	26-Apr-20	1	1.7	2.6	42	N	N
	IC	MF3-6M[(a)]	26-Apr-20	1	3.2	2.5	25	N	N
	IC	MF3-6T	26-Apr-20	1	2.4	3.3	32	N	N
	IC	MF3-7B	23-Apr-20	1	2.6	2.6	0	N	N
	IC	MF3-7M	23-Apr-20	1	3.6	3.1	15	N	N
	IC	MF3-7T	23-Apr-20	1	3.3	3.4	3	N	N
	IC	NF1B	28-Apr-20	1	3	2.5	18	N	N
	IC	NF1M	28-Apr-20	1	<1	<1	0	N	N
	IC	NF1T	28-Apr-20	1	<1	<1	0	N	N
	IC	NF2B	21-Apr-20	1	1.7	1.8	6	N	N
	IC	NF2M	21-Apr-20	1	1.9	2	5	N	N
	IC	NF2T	21-Apr-20	1	1.3	<1	89	N	N
	IC	NF3B	20-Apr-20	1	2	1.6	22	N	N
	IC	NF3M	20-Apr-20	1	1.9	1.7	11	N	N
	IC	NF3T	20-Apr-20	1	1.1	<1	75	N	N
	IC	NF4B	28-Apr-20	1	2.8	2.6	7	N	N
	IC	NF4M	28-Apr-20	1	2.6	3.4	27	N	N
	IC	NF4M[(a)]	28-Apr-20	1	2.3	3	26	N	N
	IC	NF4T	28-Apr-20	1	4.2	6.2	39	Y	N
	IC	NF5B	01-May-20	1	<1	<1	0	N	N
	IC	NF5M	01-May-20	1	<1	<1	0	N	N
	IC	NF5T	01-May-20	1	6.9	6.2	11	Y	N

Table C-5 Summary of Duplicate Sample Results for Nutrient Variables, Ice-cover Season, 2020 (continued)

Variable	Season	Station	Sample Date	DL (µg/L)	Result 1 (µg/L)	Result 2 (µg/L)	Relative Percent Difference (%)	>5 × DL?	QC Fail?
Nitrate + Nitrite (µg-N/L)	IC	FF1-2M	22-Apr-20	2	<2	3.3	107	N	N
	IC	FF2-2B	29-Apr-20	2	87	86	1	Y	N
	IC	FF2-2M	29-Apr-20	2	59	60	2	Y	N
	IC	FF2-2T	29-Apr-20	2	37	36	3	Y	N
	IC	FF2-5B	29-Apr-20	2	53	79	39	Y	N
	IC	FF2-5M	29-Apr-20	2	62	60	3	Y	N
	IC	FF2-5T	29-Apr-20	2	28	28	0	Y	N
	IC	FFD-1M	23-Apr-20	2	<2	51	192	Y	Y
	IC	LDG-48	25-Apr-20	2	<2	<2	0	N	N
	IC	MF1-1B	21-Apr-20	2	120	100	18	Y	N
	IC	MF1-1M	21-Apr-20	2	65	63	3	Y	N
	IC	MF1-1T	21-Apr-20	2	36	37	3	Y	N
	IC	MF1-3B	21-Apr-20	2	95	94	1	Y	N
	IC	MF1-3M	21-Apr-20	2	70	71	1	Y	N
	IC	MF1-3T	21-Apr-20	2	34	34	0	Y	N
	IC	MF1-5B	22-Apr-20	2	65	66	2	Y	N
	IC	MF1-5M	22-Apr-20	2	19	22	15	Y	N
	IC	MF1-5T	22-Apr-20	2	<2	<2	0	N	N
	IC	MF2-1B	27-Apr-20	2	140	160	13	Y	N
	IC	MF2-1M	27-Apr-20	2	99	85	15	Y	N
	IC	MF2-1T	27-Apr-20	2	16	15	7	Y	N
	IC	MF2-3B	01-May-20	2	71	75	6	Y	N
	IC	MF2-3M	01-May-20	2	52	47	10	Y	N
	IC	MF2-3T	01-May-20	2	33	34	3	Y	N
	IC	MF3-1B	27-Apr-20	2	100	88	13	Y	N
	IC	MF3-1M	27-Apr-20	2	37	55	39	Y	N
	IC	MF3-1T	27-Apr-20	2	11	20	58	Y	Y
	IC	MF3-2B	27-Apr-20	2	63	64	2	Y	N
	IC	MF3-2M	27-Apr-20	2	54	51	6	Y	N
	IC	MF3-2T	27-Apr-20	2	11	8.5	26	Y	N
	IC	MF3-3B	25-Apr-20	2	50	50	0	Y	N
	IC	MF3-3M	25-Apr-20	2	44	44	0	Y	N
	IC	MF3-3T	25-Apr-20	2	6.2	4.6	30	N	N
	IC	MF3-4B	26-Apr-20	2	55	49	12	Y	N
	IC	MF3-4M	26-Apr-20	2	39	37	5	Y	N
	IC	MF3-4T	26-Apr-20	2	5.8	5.6	4	N	N
	IC	MF3-5B	26-Apr-20	2	44	48	9	Y	N
	IC	MF3-5M	26-Apr-20	2	17	12	35	Y	N
	IC	MF3-5T	26-Apr-20	2	<2	2.9	97	N	N
	IC	MF3-6B	26-Apr-20	2	13	18	32	Y	N
	IC	MF3-6M	26-Apr-20	2	6.3	8.5	30	N	N
	IC	MF3-6M(a)	26-Apr-20	2	8.3	8.4	1	N	N
	IC	MF3-6T	26-Apr-20	2	2.4	5.4	77	N	N
	IC	MF3-7B	23-Apr-20	2	19	20	5	Y	N
	IC	MF3-7M	23-Apr-20	2	8.3	7.2	14	N	N
	IC	MF3-7T	23-Apr-20	2	3.3	3.5	6	N	N
	IC	NF1B	28-Apr-20	2	170	180	6	Y	N
	IC	NF1M	28-Apr-20	2	130	130	0	Y	N
	IC	NF1T	28-Apr-20	2	42	41	2	Y	N
	IC	NF2B	21-Apr-20	2	140	140	0	Y	N
	IC	NF2M	21-Apr-20	2	130	130	0	Y	N
	IC	NF2T	21-Apr-20	2	30	30	0	Y	N
	IC	NF3B	20-Apr-20	2	140	140	0	Y	N
	IC	NF3M	20-Apr-20	2	100	94	6	Y	N
	IC	NF3T	20-Apr-20	2	33	31	6	Y	N
	IC	NF4B	28-Apr-20	2	190	190	0	Y	N
	IC	NF4M	28-Apr-20	2	130	120	8	Y	N
	IC	NF4M(a)	28-Apr-20	2	120	130	8	Y	N
	IC	NF4T	28-Apr-20	2	45	47	4	Y	N
	IC	NF5B	01-May-20	2	160	160	0	Y	N
	IC	NF5M	01-May-20	2	120	110	9	Y	N
	IC	NF5T	01-May-20	2	41	43	5	Y	N

Table C-5 Summary of Duplicate Sample Results for Nutrient Variables, Ice-cover Season, 2020 (continued)

Variable	Season	Station	Sample Date	DL (µg/L)	Result 1 (µg/L)	Result 2 (µg/L)	Relative Percent Difference (%)	>5 × DL?	QC Fail?
Total Kjeldahl Nitrogen (µg-N/L)	IC	FF1-2M	22-Apr-20	20	150	160	7	Y	N
	IC	FF2-2B	29-Apr-20	20	180	210	15	Y	N
	IC	FF2-2M	29-Apr-20	20	220	180	20	Y	N
	IC	FF2-2T	29-Apr-20	20	270	270	0	Y	N
	IC	FF2-5B	29-Apr-20	20	220	270	20	Y	N
	IC	FF2-5M	29-Apr-20	20	210	250	17	Y	N
	IC	FF2-5T	29-Apr-20	20	240	300	22	Y	N
	IC	FFD-1M	23-Apr-20	20	200	150	29	Y	N
	IC	LDG-48	25-Apr-20	20	210	220	5	Y	N
	IC	MF1-1B	21-Apr-20	20	190	200	5	Y	N
	IC	MF1-1M	21-Apr-20	20	190	190	0	Y	N
	IC	MF1-1T	21-Apr-20	20	240	210	13	Y	N
	IC	MF1-3B	21-Apr-20	20	170	150	13	Y	N
	IC	MF1-3M	21-Apr-20	20	150	160	7	Y	N
	IC	MF1-3T	21-Apr-20	20	210	190	10	Y	N
	IC	MF1-5B	22-Apr-20	20	200	170	16	Y	N
	IC	MF1-5M	22-Apr-20	20	180	150	18	Y	N
	IC	MF1-5T	22-Apr-20	20	180	150	18	Y	N
	IC	MF2-1B	27-Apr-20	20	210	190	10	Y	N
	IC	MF2-1M	27-Apr-20	20	190	170	11	Y	N
	IC	MF2-1T	27-Apr-20	20	220	230	4	Y	N
	IC	MF2-3B	01-May-20	20	210	220	5	Y	N
	IC	MF2-3M	01-May-20	20	180	200	11	Y	N
	IC	MF2-3T	01-May-20	20	260	300	14	Y	N
	IC	MF3-1B	27-Apr-20	20	180	170	6	Y	N
	IC	MF3-1M	27-Apr-20	20	190	170	11	Y	N
	IC	MF3-1T	27-Apr-20	20	180	180	0	Y	N
	IC	MF3-2B	27-Apr-20	20	150	160	7	Y	N
	IC	MF3-2M	27-Apr-20	20	170	180	6	Y	N
	IC	MF3-2T	27-Apr-20	20	160	160	0	Y	N
	IC	MF3-3B	25-Apr-20	20	220	250	13	Y	N
	IC	MF3-3M	25-Apr-20	20	220	230	4	Y	N
	IC	MF3-3T	25-Apr-20	20	150	160	7	Y	N
	IC	MF3-4B	26-Apr-20	20	190	160	17	Y	N
	IC	MF3-4M	26-Apr-20	20	210	190	10	Y	N
	IC	MF3-4T	26-Apr-20	20	180	170	6	Y	N
	IC	MF3-5B	26-Apr-20	20	180	150	18	Y	N
	IC	MF3-5M	26-Apr-20	20	160	170	6	Y	N
	IC	MF3-5T	26-Apr-20	20	160	180	12	Y	N
	IC	MF3-6B	26-Apr-20	20	160	160	0	Y	N
	IC	MF3-6M	26-Apr-20	20	170	190	11	Y	N
	IC	MF3-6M(a)	26-Apr-20	20	160	170	6	Y	N
	IC	MF3-6T	26-Apr-20	20	170	180	6	Y	N
	IC	MF3-7B	23-Apr-20	20	140	180	25	Y	N
	IC	MF3-7M	23-Apr-20	20	160	160	0	Y	N
	IC	MF3-7T	23-Apr-20	20	170	<20(b)	178	Y	Y
	IC	NF1B	28-Apr-20	20	270	230	16	Y	N
	IC	NF1M	28-Apr-20	20	200	230	14	Y	N
	IC	NF1T	28-Apr-20	20	270	230	16	Y	N
	IC	NF2B	21-Apr-20	20	220	190	15	Y	N
	IC	NF2M	21-Apr-20	20	210	210	0	Y	N
	IC	NF2T	21-Apr-20	20	170	180	6	Y	N
	IC	NF3B	20-Apr-20	20	220	210	5	Y	N
	IC	NF3M	20-Apr-20	20	170	180	6	Y	N
	IC	NF3T	20-Apr-20	20	200	190	5	Y	N
	IC	NF4B	28-Apr-20	20	160	260	48	Y	Y
	IC	NF4M	28-Apr-20	20	220	230	4	N	N
	IC	NF4M(a)	28-Apr-20	20	220	210	5	N	N
	IC	NF4T	28-Apr-20	20	220	250	13	Y	N
	IC	NF5B	01-May-20	20	220	250	13	Y	N
	IC	NF5M	01-May-20	20	200	210	5	Y	N
	IC	NF5T	01-May-20	20	210	200	5	Y	N

Table C-5 Summary of Duplicate Sample Results for Nutrient Variables, Ice-cover Season, 2020 (continued)

Variable	Season	Station	Sample Date	DL (µg/L)	Result 1 (µg/L)	Result 2 (µg/L)	Relative Percent Difference (%)	>5 × DL?	QC Fail?
Dissolved Kjeldahl Nitrogen (µg-N/L)	IC	FF1-2M	22-Apr-20	20	180	190	5	Y	N
	IC	FF2-2B	29-Apr-20	20	160	190	17	Y	N
	IC	FF2-2M	29-Apr-20	20	160	160	0	Y	N
	IC	FF2-2T	29-Apr-20	20	260	250	4	Y	N
	IC	FF2-5B	29-Apr-20	20	210	180	15	Y	N
	IC	FF2-5M	29-Apr-20	20	170	150	13	Y	N
	IC	FF2-5T	29-Apr-20	20	220	220	0	Y	N
	IC	FFD-1M	23-Apr-20	20	200	170	16	Y	N
	IC	LDG-48	25-Apr-20	20	200	200	0	Y	N
	IC	MF1-1B	21-Apr-20	20	140	150	7	Y	N
	IC	MF1-1M	21-Apr-20	20	210	140	40	Y	N
	IC	MF1-1T	21-Apr-20	20	170	190	11	Y	N
	IC	MF1-3B	21-Apr-20	20	130	130	0	Y	N
	IC	MF1-3M	21-Apr-20	20	130	130	0	Y	N
	IC	MF1-3T	21-Apr-20	20	140	150	7	Y	N
	IC	MF1-5B	22-Apr-20	20	190	200	5	Y	N
	IC	MF1-5M	22-Apr-20	20	210	200	5	Y	N
	IC	MF1-5T	22-Apr-20	20	190	250	27	Y	N
	IC	MF2-1B	27-Apr-20	20	230	220	4	Y	N
	IC	MF2-1M	27-Apr-20	20	220	210	5	Y	N
	IC	MF2-1T	27-Apr-20	20	240	240	0	Y	N
	IC	MF2-3B	01-May-20	20	160	140	13	Y	N
	IC	MF2-3M	01-May-20	20	150	170	13	Y	N
	IC	MF2-3T	01-May-20	20	220	190	15	Y	N
	IC	MF3-1B	27-Apr-20	20	220	220	0	Y	N
	IC	MF3-1M	27-Apr-20	20	230	180	24	Y	N
	IC	MF3-1T	27-Apr-20	20	230	230	0	Y	N
	IC	MF3-2B	27-Apr-20	20	150	170	13	Y	N
	IC	MF3-2M	27-Apr-20	20	160	160	0	Y	N
	IC	MF3-2T	27-Apr-20	20	170	150	13	Y	N
	IC	MF3-3B	25-Apr-20	20	150	140	7	Y	N
	IC	MF3-3M	25-Apr-20	20	140	140	0	Y	N
	IC	MF3-3T	25-Apr-20	20	200	190	5	Y	N
	IC	MF3-4B	26-Apr-20	20	140	140	0	Y	N
	IC	MF3-4M	26-Apr-20	20	150	160	7	Y	N
	IC	MF3-4T	26-Apr-20	20	160	160	0	Y	N
	IC	MF3-5B	26-Apr-20	20	140	170	19	Y	N
	IC	MF3-5M	26-Apr-20	20	130	170	27	Y	N
	IC	MF3-5T	26-Apr-20	20	160	150	7	Y	N
	IC	MF3-6B	26-Apr-20	20	140	140	0	Y	N
	IC	MF3-6M	26-Apr-20	20	130	130	0	Y	N
	IC	MF3-6M(a)	26-Apr-20	20	140	140	0	Y	N
	IC	MF3-6T	26-Apr-20	20	150	140	7	Y	N
	IC	MF3-7B	23-Apr-20	20	150	140	7	Y	N
	IC	MF3-7M	23-Apr-20	20	140	130	7	Y	N
	IC	MF3-7T	23-Apr-20	20	140	130	7	Y	N
	IC	NF1B	28-Apr-20	20	210	200	5	Y	N
	IC	NF1M	28-Apr-20	20	170	180	6	Y	N
	IC	NF1T	28-Apr-20	20	190	190	0	Y	N
	IC	NF2B	21-Apr-20	20	160	160	0	Y	N
	IC	NF2M	21-Apr-20	20	160	150	7	Y	N
	IC	NF2T	21-Apr-20	20	140	140	0	Y	N
	IC	NF3B	20-Apr-20	20	160	160	0	Y	N
	IC	NF3M	20-Apr-20	20	150	150	0	Y	N
	IC	NF3T	20-Apr-20	20	160	140	13	Y	N
	IC	NF4B	28-Apr-20	20	180	200	11	Y	N
	IC	NF4M	28-Apr-20	20	170	170	0	Y	N
	IC	NF4M(a)	28-Apr-20	20	170	190	11	Y	N
	IC	NF4T	28-Apr-20	20	200	190	5	Y	N
	IC	NF5B	01-May-20	20	150	180	18	Y	N
	IC	NF5M	01-May-20	20	170	170	0	Y	N
	IC	NF5T	01-May-20	20	190	190	0	Y	N

Table C-5 Summary of Duplicate Sample Results for Nutrient Variables, Ice-cover Season, 2020 (continued)

Variable	Season	Station	Sample Date	DL (µg/L)	Result 1 (µg/L)	Result 2 (µg/L)	Relative Percent Difference (%)	>5 × DL?	QC Fail?
Soluble Reactive Silica (µg/L)	IC	FF1-2M	22-Apr-20	10	99	100	1	Y	N
	IC	FF2-2B	29-Apr-20	10	110	115	4	Y	N
	IC	FF2-2M	29-Apr-20	10	77	75	3	Y	N
	IC	FF2-2T	29-Apr-20	10	88	85	4	Y	N
	IC	FF2-5B	29-Apr-20	10	185	171	8	Y	N
	IC	FF2-5M	29-Apr-20	10	72	71	1	Y	N
	IC	FF2-5T	29-Apr-20	10	130	132	2	Y	N
	IC	FFD-1M	23-Apr-20	10	71	87	20	Y	N
	IC	LDG-48	25-Apr-20	10	63	65	3	Y	N
	IC	MF1-1B	21-Apr-20	10	326	298	9	Y	N
	IC	MF1-1M	21-Apr-20	10	164	161	2	Y	N
	IC	MF1-1T	21-Apr-20	10	119	123	3	Y	N
	IC	MF1-3B	21-Apr-20	10	224	221	1	Y	N
	IC	MF1-3M	21-Apr-20	10	144	147	2	Y	N
	IC	MF1-3T	21-Apr-20	10	110	109	1	Y	N
	IC	MF1-5B	22-Apr-20	10	851	881	4	Y	N
	IC	MF1-5M	22-Apr-20	10	170	179	5	Y	N
	IC	MF1-5T	22-Apr-20	10	80	79	1	Y	N
	IC	MF2-1B	27-Apr-20	10	627	650	4	Y	N
	IC	MF2-1M	27-Apr-20	10	286	211	30	Y	N
	IC	MF2-1T	27-Apr-20	10	124	111	11	Y	N
	IC	MF2-3B	01-May-20	10	95	93	2	Y	N
	IC	MF2-3M	01-May-20	10	77	64	18	Y	N
	IC	MF2-3T	01-May-20	10	72	71	1	Y	N
	IC	MF3-1B	27-Apr-20	10	459	456	1	Y	N
	IC	MF3-1M	27-Apr-20	10	146	148	1	Y	N
	IC	MF3-1T	27-Apr-20	10	98	101	3	Y	N
	IC	MF3-2B	27-Apr-20	10	174	181	4	Y	N
	IC	MF3-2M	27-Apr-20	10	141	146	4	Y	N
	IC	MF3-2T	27-Apr-20	10	72	70	3	Y	N
	IC	MF3-3B	25-Apr-20	10	131	137	5	Y	N
	IC	MF3-3M	25-Apr-20	10	120	117	3	Y	N
	IC	MF3-3T	25-Apr-20	10	61	62	2	Y	N
	IC	MF3-4B	26-Apr-20	10/50	138	135	2	Y/N	N
	IC	MF3-4M	26-Apr-20	10	100	98	2	Y	N
	IC	MF3-4T	26-Apr-20	10	62	69	11	Y	N
	IC	MF3-5B	26-Apr-20	10	206	212	3	Y	N
	IC	MF3-5M	26-Apr-20	10	83	77	8	Y	N
	IC	MF3-5T	26-Apr-20	10	59	58	2	Y	N
	IC	MF3-6B	26-Apr-20	10	64	74	15	Y	N
	IC	MF3-6M	26-Apr-20	10	67	64	5	Y	N
	IC	MF3-6M(a)	26-Apr-20	10	62	61	2	Y	N
	IC	MF3-6T	26-Apr-20	10	59	58	2	Y	N
	IC	MF3-7B	23-Apr-20	10	102	103	1	Y	N
	IC	MF3-7M	23-Apr-20	10	58	60	3	Y	N
	IC	MF3-7T	23-Apr-20	10	49	49	0	N	N
	IC	NF1B	28-Apr-20	10	970	943	3	Y	N
	IC	NF1M	28-Apr-20	10	383	421	10	Y	N
	IC	NF1T	28-Apr-20	10	120	120	0	Y	N
	IC	NF2B	21-Apr-20	10	996	1040	4	Y	N
	IC	NF2M	21-Apr-20	10	765	832	8	Y	N
	IC	NF2T	21-Apr-20	10	128	123	4	Y	N
	IC	NF3B	20-Apr-20	10	928	946	2	Y	N
	IC	NF3M	20-Apr-20	10	420	362	15	Y	N
	IC	NF3T	20-Apr-20	10	132	131	1	Y	N
	IC	NF4B	28-Apr-20	10	840	828	1	Y	N
	IC	NF4M	28-Apr-20	10	340	332	2	Y	N
	IC	NF4M(a)	28-Apr-20	10	342	356	4	Y	N
	IC	NF4T	28-Apr-20	10	95	125	27	Y	N
	IC	NF5B	01-May-20	10	892	875	2	Y	N
	IC	NF5M	01-May-20	10	439	406	8	Y	N
	IC	NF5T	01-May-20	10	126	113	11	Y	N

Note: "Y" in "QC Fail?" column indicates a QC flag for relative percent difference (RPD) values that were greater than 40%, where concentrations in one or both of the duplicate samples were greater than or equal to five times the corresponding DL.
a) Duplicate sample collected for QA/QC purposes.
b) Value removed from dataset as a result of data QAQC.
c) Value identified as anomalous value in screening step (Attachment B).
µg-N/L = micrograms nitrogen per litre; µg-P/L = micrograms phosphorus per litre; µg/L = micrograms per litre; DL = detection limit; < = less than; > = greater than; × = times; QC = quality control; IC = ice-cover; NF = near-field; MF = mid-field; FF = far-field; N = no; Y = yes.

Table C-6 Summary of Duplicate Sample Results for Nutrient Variables, Open-water Season, 2020

Variable	Season	Station	Sample Date	DL (µg/L)	Result 1 (µg/L)	Result 2 (µg/L)	Relative Percent Difference (%)	>5 × DL?	QC Fail?
Total Phosphorus (µg-P/L)	OW	FF1-2	18-Aug-20	2	2	3.2	46	N	N
	OW	FF2-2	19-Aug-20	2	<2	<2	0	N	N
	OW	FF2-5	19-Aug-20	2	<2	2.4	82	N	N
	OW	FFD-1	18-Aug-20	2	<2	<2	0	N	N
	OW	LDG-48	16-Aug-20	2	<2	<2	0	N	N
	OW	LDS-4	16-Aug-20	2	2.8	2.5	11	N	N
	OW	MF1-1	31-Aug-20	2	2	2.2	10	N	N
	OW	MF1-3	31-Aug-20	2	<2	5.6	139	N	N
	OW	MF1-5	31-Aug-20	2	<2	2.1	71	N	N
	OW	MF2-1	28-Aug-20	2	2.4	9.9(b)	122	N	N
	OW	MF2-3	28-Aug-20	2	2.7	<2	92	N	N
	OW	MF3-1	28-Aug-20	2	<2	<2	0	N	N
	OW	MF3-2	27-Aug-20	2	<2	<2	0	N	N
	OW	MF3-3	22-Aug-20	2	<2	<2	0	N	N
	OW	MF3-4	22-Aug-20	2	<2	<2	0	N	N
	OW	MF3-5	21-Aug-20	2	<2	<2	0	N	N
	OW	MF3-6	21-Aug-20	2	<2	<2	0	N	N
	OW	MF3-7	21-Aug-20	2	<2	3.9	118	N	N
	OW	NF1	07-Sep-20	2	4.6	<2	129	N	N
	OW	NF2	07-Sep-20	2	<2	<2	0	N	N
	OW	NF3	07-Sep-20	2	<2	2.1	71	N	N
	OW	NF4	29-Aug-20	2	2.9	<2	97	N	N
	OW	NF5	29-Aug-20	2	5.1	<2	134	N	N
Total Dissolved Phosphorus (µg-P/L)	OW	FF1-2	18-Aug-20	2	<2	<2	0	N	N
	OW	FF2-2	19-Aug-20	2	<2	<2	0	N	N
	OW	FF2-5	19-Aug-20	2	<2	<2	0	N	N
	OW	FFD-1	18-Aug-20	2	<2	<2	0	N	N
	OW	LDG-48	16-Aug-20	2	<2	<2	0	N	N
	OW	LDS-4	16-Aug-20	2	<2	<2	0	N	N
	OW	MF1-1	31-Aug-20	2	<2	<2	0	N	N
	OW	MF1-3	31-Aug-20	2	<2	<2	0	N	N
	OW	MF1-5	31-Aug-20	2	<2	<2	0	N	N
	OW	MF2-1	28-Aug-20	2	<2	<2	0	N	N
	OW	MF2-3	28-Aug-20	2	<2	<2	0	N	N
	OW	MF3-1	28-Aug-20	2	<2	<2	0	N	N
	OW	MF3-2	27-Aug-20	2	<2	<2	0	N	N
	OW	MF3-3	22-Aug-20	2	<2	<2	0	N	N
	OW	MF3-4	22-Aug-20	2	<2	<2	0	N	N
	OW	MF3-5	21-Aug-20	2	<2	11.9(a)	169	Y	Y
	OW	MF3-6	21-Aug-20	2	<2	<2	0	N	N
	OW	MF3-7	21-Aug-20	2	<2	<2	0	N	N
	OW	NF1	07-Sep-20	2	<2	<2	0	N	N
	OW	NF2	07-Sep-20	2	<2	<2	0	N	N
	OW	NF3	07-Sep-20	2	<2	<2	0	N	N
	OW	NF4	29-Aug-20	2	<2	<2	0	N	N
	OW	NF5	29-Aug-20	2	<2	<2	0	N	N
Soluble Reactive Phosphorus (µg-P/L)	OW	FF1-2	18-Aug-20	1	<1	<1	0	N	N
	OW	FF2-2	19-Aug-20	1	<1	<1	0	N	N
	OW	FF2-5	19-Aug-20	1	<1	<1	0	N	N
	OW	FFD-1	18-Aug-20	1	<1	<1	0	N	N
	OW	LDG-48	16-Aug-20	1	<1	<1	0	N	N
	OW	LDS-4	16-Aug-20	1	<1	<1	0	N	N
	OW	MF1-1	31-Aug-20	1	<1	<1	0	N	N
	OW	MF1-3	31-Aug-20	1	<1	<1	0	N	N
	OW	MF1-5	31-Aug-20	1	<1	<1	0	N	N
	OW	MF2-1	28-Aug-20	1	<1	<1	0	N	N
	OW	MF2-3	28-Aug-20	1	<1	<1	0	N	N
	OW	MF3-1	28-Aug-20	1	<1	3.3	147	N	N
	OW	MF3-2	27-Aug-20	1	<1	<1	0	N	N
	OW	MF3-3	22-Aug-20	1	<1	<1	0	N	N
	OW	MF3-4	22-Aug-20	1	<1	<1	0	N	N
	OW	MF3-5	21-Aug-20	1	<1	<1	0	N	N
	OW	MF3-6	21-Aug-20	1	<1	<1	0	N	N
	OW	MF3-7	21-Aug-20	1	<1	<1	0	N	N

Table C-6 Summary of Duplicate Sample Results for Nutrient Variables, Open-water Season, 2020 (continued)

Variable	Season	Station	Sample Date	DL (µg/L)	Result 1 (µg/L)	Result 2 (µg/L)	Relative Percent Difference (%)	>5 × DL?	QC Fail?
	OW	NF1	07-Sep-20	1	<1	<1	0	N	N
	OW	NF2	07-Sep-20	1	1.6	<1	105	N	N
	OW	NF3	07-Sep-20	1	1	2.3	79	N	N
	OW	NF4	29-Aug-20	1	<1	<1	0	N	N
	OW	NF5	29-Aug-20	1	<1	<1	0	N	N
Total Nitrogen (µg-N/L)	OW	FF1-2	18-Aug-20	20	120	150	22	Y	N
	OW	FF2-2	19-Aug-20	20	200	200	0	Y	N
	OW	FF2-5	19-Aug-20	20	510	550	8	Y	N
	OW	FFD-1	18-Aug-20	20	470	480	2	Y	N
	OW	LDG-48	16-Aug-20	20	130	120	8	Y	N
	OW	LDS-4	16-Aug-20	20	140	170	19	Y	N
	OW	MF1-1	31-Aug-20	20	180	290	47	Y	Y
	OW	MF1-3	31-Aug-20	20	270	170	46	Y	Y
	OW	MF1-5	31-Aug-20	20	140	150	7	Y	N
	OW	MF2-1	28-Aug-20	20	200	200	0	Y	N
	OW	MF2-3	28-Aug-20	20	170	160	6	Y	N
	OW	MF3-1	28-Aug-20	20	180	160	12	Y	N
	OW	MF3-2	27-Aug-20	20	140	150	7	Y	N
	OW	MF3-3	22-Aug-20	20	240	160	40	Y	N
	OW	MF3-4	22-Aug-20	20	140	110	24	Y	N
	OW	MF3-5	21-Aug-20	20	140	450	105	Y	Y
	OW	MF3-6	21-Aug-20	20	140	130	7	Y	N
	OW	MF3-7	21-Aug-20	20	110	110	0	Y	N
	OW	NF1	07-Sep-20	20	270	280	4	Y	N
	OW	NF2	07-Sep-20	20	210	190	10	Y	N
	OW	NF3	07-Sep-20	20	230	240	4	Y	N
	OW	NF4	29-Aug-20	20	220	220	0	Y	N
	OW	NF5	29-Aug-20	20	230	220	4	Y	N
Total Dissolved Nitrogen (µg-N/L)	OW	FF1-2	18-Aug-20	20	180	210	15	Y	N
	OW	FF2-2	19-Aug-20	20	180	160	12	Y	N
	OW	FF2-5	19-Aug-20	20	330	190	54	Y	Y
	OW	FFD-1	18-Aug-20	20	140	120	15	Y	N
	OW	LDG-48	16-Aug-20	20	120	130	8	Y	N
	OW	LDS-4	16-Aug-20	20	150	160	7	Y	N
	OW	MF1-1	31-Aug-20	20	190	170	11	Y	N
	OW	MF1-3	31-Aug-20	20	140	140	0	Y	N
	OW	MF1-5	31-Aug-20	20	120	120	0	Y	N
	OW	MF2-1	28-Aug-20	20	160	180	12	Y	N
	OW	MF2-3	28-Aug-20	20	200	190	5	Y	N
	OW	MF3-1	28-Aug-20	20	160	170	6	Y	N
	OW	MF3-2	27-Aug-20	20	140	130	7	Y	N
	OW	MF3-3	22-Aug-20	20	130	130	0	Y	N
	OW	MF3-4	22-Aug-20	20	130	180	32	Y	N
	OW	MF3-5	21-Aug-20	20	120	140	15	Y	N
	OW	MF3-6	21-Aug-20	20	140	110	24	Y	N
	OW	MF3-7	21-Aug-20	20	130	180	32	Y	N
	OW	NF1	07-Sep-20	20	220	13000[(a)]	193	Y	Y
	OW	NF2	07-Sep-20	20	240	220	9	Y	N
	OW	NF3	07-Sep-20	20	230	270	16	Y	N
	OW	NF4	29-Aug-20	20	160	170	6	Y	N
	OW	NF5	29-Aug-20	20	200	210	5	Y	N
Total Ammonia (µg-N/L) - ALS	OW	FF1-2	18-Aug-20	5	<5	22.6	160	N	N
	OW	FF2-2	19-Aug-20	5	15.5	8	64	N	N
	OW	FF2-5	19-Aug-20	5	55.1	7.2	154	Y	Y
	OW	FFD-1	18-Aug-20	5	<5	<5	0	N	N
	OW	LDG-48	16-Aug-20	5	<5	<5	0	N	N
	OW	LDS-4	16-Aug-20	5	6.1	<5	84	N	N
	OW	MF1-1	31-Aug-20	5	<5	5.2	70	N	N
	OW	MF1-3	31-Aug-20	5	6.7	36.1	137	Y	Y
	OW	MF1-5	31-Aug-20	5	17.1	<5	149	N	N
	OW	MF2-1	28-Aug-20	5	7.6	7.3	4	N	N
	OW	MF2-3	28-Aug-20	5	6.8	17.4	88	N	N
	OW	MF3-1	28-Aug-20	5	22	20	10	N	N
	OW	MF3-2	27-Aug-20	5	7.8	8.6	10	N	N
	OW	MF3-3	22-Aug-20	5	<5	11	127	N	N

Table C-6 Summary of Duplicate Sample Results for Nutrient Variables, Open-water Season, 2020 (continued)

Variable	Season	Station	Sample Date	DL (µg/L)	Result 1 (µg/L)	Result 2 (µg/L)	Relative Percent Difference (%)	>5 × DL?	QC Fail?
	OW	MF3-4	22-Aug-20	5	<5	<5	0	N	N
	OW	MF3-5	21-Aug-20	5	<5	23.4	161	N	N
	OW	MF3-6	21-Aug-20	5	<5	<5	0	N	N
	OW	MF3-7	21-Aug-20	5	<5	14.9	143	N	N
	OW	NF1	07-Sep-20	5	5.8	11.9	69	N	N
	OW	NF2	07-Sep-20	5	8.7	32.5	116	Y	Y
	OW	NF3	07-Sep-20	5	9.1	5.9	43	N	N
	OW	NF4	29-Aug-20	5	6.5	9.6	39	N	N
	OW	NF5	29-Aug-20	5	40.9	6.7	144	Y	Y
Total Ammonia (µg-N/L) - BV Labs	OW	FF1-2	18-Aug-20	5	8.4	<5	108	N	N
	OW	FF2-2	19-Aug-20	5	66	12	139	Y	Y
	OW	FF2-5	19-Aug-20	5	25	15	50	N	N
	OW	FFD-1	18-Aug-20	5	9.8	8.7	12	N	N
	OW	LDG-48	16-Aug-20	5	<5	<5	0	N	N
	OW	LDS-4	16-Aug-20	5	<5	<5	0	N	N
	OW	MF1-1	31-Aug-20	5	6.8	6.6	3	N	N
	OW	MF1-3	31-Aug-20	5	9.7	7	32	N	N
	OW	MF1-5	31-Aug-20	5	6	8.6	36	N	N
	OW	MF2-1	28-Aug-20	5	15	10	40	N	N
	OW	MF2-3	28-Aug-20	5	19	9.8	64	N	N
	OW	MF3-1	28-Aug-20	5	9.1	12	28	N	N
	OW	MF3-2	27-Aug-20	5	7.1	7	1	N	N
	OW	MF3-3	22-Aug-20	5	9.7	13	29	N	N
	OW	MF3-4	22-Aug-20	5	15	31	70	Y	Y
	OW	MF3-5	21-Aug-20	5	6	28	129	Y	Y
	OW	MF3-6	21-Aug-20	5	54	7.4	152	Y	Y
	OW	MF3-7	21-Aug-20	5	7.4	6.1	19	N	N
	OW	NF1	07-Sep-20	5	8.8	11	22	N	N
	OW	NF2	07-Sep-20	5	52	46	12	Y	N
	OW	NF3	07-Sep-20	5	8	7.5	7	N	N
	OW	NF4	29-Aug-20	5	21	16	27	N	N
	OW	NF5	29-Aug-20	5	10	12	18	N	N
Nitrate (µg-N/L)	OW	FF1-2	18-Aug-20	2	<2	<2	0	N	N
	OW	FF2-2	19-Aug-20	2	15	16	7	Y	N
	OW	FF2-5	19-Aug-20	2	18	17	6	Y	N
	OW	FFD-1	18-Aug-20	2	<2	<2	0	N	N
	OW	LDG-48	16-Aug-20	2	<2	<2	0	N	N
	OW	LDS-4	16-Aug-20	2	<2	2.5	86	N	N
	OW	MF1-1	31-Aug-20	2	27	20	30	Y	N
	OW	MF1-3	31-Aug-20	2	7.3	4.4	50	N	N
	OW	MF1-5	31-Aug-20	2	<2	3.7	115	N	N
	OW	MF2-1	28-Aug-20	2	23	22	4	Y	N
	OW	MF2-3	28-Aug-20	2	21	18	15	Y	N
	OW	MF3-1	28-Aug-20	2	11	12	9	Y	N
	OW	MF3-2	27-Aug-20	2	<2	3.2	105	N	N
	OW	MF3-3	22-Aug-20	2	<2	<2	0	N	N
	OW	MF3-4	22-Aug-20	2	<2	<2	0	N	N
	OW	MF3-5	21-Aug-20	2	<2	<2	0	N	N
	OW	MF3-6	21-Aug-20	2	<2	<2	0	N	N
	OW	MF3-7	21-Aug-20	2	<2	<2	0	N	N
	OW	NF1	07-Sep-20	2	59	63	7	Y	N
	OW	NF2	07-Sep-20	2	51	48	6	Y	N
	OW	NF3	07-Sep-20	2	69	50	32	Y	N
	OW	NF4	29-Aug-20	2	37	39	5	Y	N
	OW	NF5	29-Aug-20	2	47	51	8	Y	N
Nitrite (µg-N/L)	OW	FF1-2	18-Aug-20	1	<1	<1	0	N	N
	OW	FF2-2	19-Aug-20	1	<1	<1	0	N	N
	OW	FF2-5	19-Aug-20	1	2.5	<1	133	N	N
	OW	FFD-1	18-Aug-20	1	<1	<1	0	N	N
	OW	LDG-48	16-Aug-20	1	<1	<1	0	N	N
	OW	LDS-4	16-Aug-20	1	<1	<1	0	N	N
	OW	MF1-1	31-Aug-20	1	2.3	<1	129	N	N
	OW	MF1-3	31-Aug-20	1	<1	<1	0	N	N
	OW	MF1-5	31-Aug-20	1	<1	<1	0	N	N
	OW	MF2-1	28-Aug-20	1	<1	<1	0	N	N

Table C-6 Summary of Duplicate Sample Results for Nutrient Variables, Open-water Season, 2020 (continued)

Variable	Season	Station	Sample Date	DL (µg/L)	Result 1 (µg/L)	Result 2 (µg/L)	Relative Percent Difference (%)	>5 × DL?	QC Fail?
	OW	MF2-3	28-Aug-20	1	<1	<1	0	N	N
	OW	MF3-1	28-Aug-20	1	<1	<1	0	N	N
	OW	MF3-2	27-Aug-20	1	<1	<1	0	N	N
	OW	MF3-3	22-Aug-20	1	<1	<1	0	N	N
	OW	MF3-4	22-Aug-20	1	<1	<1	0	N	N
	OW	MF3-5	21-Aug-20	1	<1	<1	0	N	N
	OW	MF3-6	21-Aug-20	1	<1	<1	0	N	N
	OW	MF3-7	21-Aug-20	1	<1	<1	0	N	N
	OW	NF1	07-Sep-20	1	2.6	2	26	N	N
	OW	NF2	07-Sep-20	1	2.5	2.2	13	N	N
	OW	NF3	07-Sep-20	1	2.6	2.5	4	N	N
	OW	NF4	29-Aug-20	1	2.7	2.7	0	N	N
	OW	NF5	29-Aug-20	1	2.9	3.1	7	N	N
Nitrate + Nitrite (µg-N/L)	OW	FF1-2	18-Aug-20	2	<2	<2	0	N	N
	OW	FF2-2	19-Aug-20	2	15	16	7	Y	N
	OW	FF2-5	19-Aug-20	2	20	17	16	Y	N
	OW	FFD-1	18-Aug-20	2	<2	<2	0	N	N
	OW	LDG-48	16-Aug-20	2	<2	<2	0	N	N
	OW	LDS-4	16-Aug-20	2	<2	<2	0	N	N
	OW	MF1-1	31-Aug-20	2	29	20	37	Y	N
	OW	MF1-3	31-Aug-20	2	7.3	4.4	50	N	N
	OW	MF1-5	31-Aug-20	2	<2	3.7	115	N	N
	OW	MF2-1	28-Aug-20	2	23	22	4	Y	N
	OW	MF2-3	28-Aug-20	2	21	18	15	Y	N
	OW	MF3-1	28-Aug-20	2	11	12	9	Y	N
	OW	MF3-2	27-Aug-20	2	<2	3.2	105	N	N
	OW	MF3-3	22-Aug-20	2	<2	<2	0	N	N
	OW	MF3-4	22-Aug-20	2	<2	<2	0	N	N
	OW	MF3-5	21-Aug-20	2	<2	<2	0	N	N
	OW	MF3-6	21-Aug-20	2	<2	<2	0	N	N
	OW	MF3-7	21-Aug-20	2	<2	<2	0	N	N
	OW	NF1	07-Sep-20	2	62	65	5	Y	N
	OW	NF2	07-Sep-20	2	53	50	6	Y	N
	OW	NF3	07-Sep-20	2	72	53	30	Y	N
	OW	NF4	29-Aug-20	2	39	42	7	Y	N
	OW	NF5	29-Aug-20	2	49	54	10	Y	N
Total Kjeldahl Nitrogen (µg-N/L)	OW	FF1-2	18-Aug-20	20	120	150	22	Y	N
	OW	FF2-2	19-Aug-20	20	190	190	0	Y	N
	OW	FF2-5	19-Aug-20	20	170	150	13	Y	N
	OW	FFD-1	18-Aug-20	20	150	150	0	Y	N
	OW	LDG-48	16-Aug-20	20	130	120	8	Y	N
	OW	LDS-4	16-Aug-20	20	140	170	19	Y	N
	OW	MF1-1	31-Aug-20	20	150	270	57	Y	Y
	OW	MF1-3	31-Aug-20	20	260	160	48	Y	Y
	OW	MF1-5	31-Aug-20	20	140	140	0	Y	N
	OW	MF2-1	28-Aug-20	20	180	180	0	Y	N
	OW	MF2-3	28-Aug-20	20	150	150	0	Y	N
	OW	MF3-1	28-Aug-20	20	170	150	13	Y	N
	OW	MF3-2	27-Aug-20	20	140	150	7	Y	N
	OW	MF3-3	22-Aug-20	20	240	160	40	Y	N
	OW	MF3-4	22-Aug-20	20	140	110	24	Y	N
	OW	MF3-5	21-Aug-20	20	140	170	19	Y	N
	OW	MF3-6	21-Aug-20	20	140	130	7	Y	N
	OW	MF3-7	21-Aug-20	20	110	110	0	Y	N
	OW	NF1	07-Sep-20	20	210	220	5	Y	N
	OW	NF2	07-Sep-20	20	160	140	13	Y	N
	OW	NF3	07-Sep-20	20	160	190	17	Y	N
	OW	NF4	29-Aug-20	20	180	180	0	Y	N
	OW	NF5	29-Aug-20	20	180	170	6	Y	N

Table C-6 Summary of Duplicate Sample Results for Nutrient Variables, Open-water Season, 2020 (continued)

Variable	Season	Station	Sample Date	DL (µg/L)	Result 1 (µg/L)	Result 2 (µg/L)	Relative Percent Difference (%)	>5 × DL?	QC Fail?
Dissolved Kjeldahl Nitrogen (µg-N/L)	OW	FF1-2	18-Aug-20	20	180	210	15	Y	N
	OW	FF2-2	19-Aug-20	20	170	150	13	Y	N
	OW	FF2-5	19-Aug-20	20	310(b)	170	58	Y	Y
	OW	FFD-1	18-Aug-20	20	140	120	15	Y	N
	OW	LDG-48	16-Aug-20	20	120	130	8	Y	N
	OW	LDS-4	16-Aug-20	20	150	150	0	Y	N
	OW	MF1-1	31-Aug-20	20	160	150	7	Y	N
	OW	MF1-3	31-Aug-20	20	140	140	0	Y	N
	OW	MF1-5	31-Aug-20	20	120	120	0	Y	N
	OW	MF2-1	28-Aug-20	20	130	160	21	Y	N
	OW	MF2-3	28-Aug-20	20	180	170	6	Y	N
	OW	MF3-1	28-Aug-20	20	150	160	7	Y	N
	OW	MF3-2	27-Aug-20	20	140	120	15	Y	N
	OW	MF3-3	22-Aug-20	20	130	130	0	Y	N
	OW	MF3-4	22-Aug-20	20	130	180	32	Y	N
	OW	MF3-5	21-Aug-20	20	120	140	15	Y	N
	OW	MF3-6	21-Aug-20	20	140	110	24	Y	N
	OW	MF3-7	21-Aug-20	20	130	180	32	Y	N
	OW	NF1	07-Sep-20	20	160	13000(a)	195	Y	Y
	OW	NF2	07-Sep-20	20	190	170	11	Y	N
	OW	NF3	07-Sep-20	20	150	210	33	Y	N
	OW	NF4	29-Aug-20	20	130	130	0	Y	N
	OW	NF5	29-Aug-20	20	150	150	0	Y	N
Soluble Reactive Silica (µg/L)	OW	FF1-2	18-Aug-20	10	93	92	1	Y	N
	OW	FF2-2	19-Aug-20	10	141	138	2	Y	N
	OW	FF2-5	19-Aug-20	10	148	144	3	Y	N
	OW	FFD-1	18-Aug-20	10	85	78	9	Y	N
	OW	LDG-48	16-Aug-20	10	134	137	2	Y	N
	OW	LDS-4	16-Aug-20	10	255	243	5	Y	N
	OW	MF1-1	31-Aug-20	10	124	126	2	Y	N
	OW	MF1-3	31-Aug-20	10	118	118	0	Y	N
	OW	MF1-5	31-Aug-20	10	92	96	4	Y	N
	OW	MF2-1	28-Aug-20	10	131	128	2	Y	N
	OW	MF2-3	28-Aug-20	10	139	137	1	Y	N
	OW	MF3-1	28-Aug-20	10	105	105	0	Y	N
	OW	MF3-2	27-Aug-20	10	84	87	4	Y	N
	OW	MF3-3	22-Aug-20	10	78	81	4	Y	N
	OW	MF3-4	22-Aug-20	10	74	76	3	Y	N
	OW	MF3-5	21-Aug-20	10	72	72	0	Y	N
	OW	MF3-6	21-Aug-20	10	73	82	12	Y	N
	OW	MF3-7	21-Aug-20	10	78	80	3	Y	N
	OW	NF1	07-Sep-20	10/50	170	167	2	Y	N
	OW	NF2	07-Sep-20	10	160	165	3	Y	N
	OW	NF3	07-Sep-20	10	161	167	4	Y	N
	OW	NF4	29-Aug-20	10	147	144	2	Y	N
	OW	NF5	29-Aug-20	10	154	158	3	Y	N

Note: "Y" in "QC Fail?" column indicates a QC flag for relative percent difference (RPD) values that were greater than 40%, where concentrations in one or both of the duplicate samples were greater than or equal to five times the corresponding DL.

a) Value removed from dataset as a result of data QAQC.

b) Value identified as anomalous value in screening step (Attachment B).

µg/L = micrograms per litre; DL = detection limit; < = less than; > = greater than; × = times; % = percent; QC = quality control; OW = open-water; NF = near-field; MF = mid-field; FF = far-field; LDG-48 = Lac de Gras outlet; LDS-4 = Lac du Sauvage Outlet (the Narrows); N = no; Y = yes.

Total Versus Dissolved Forms

The differences between TP and TDP concentrations were within DQOs except for one sample collected during the open-water season (Table C-7). Given the lack of DQO failures for TDP in both seasons with this exception, the data were considered acceptable.

Due to issues with field contamination that were observed in 2018, samples for TDN and DKN analysis were filtered at the analytical laboratory in subsequent years. This change has improved the quality of the dataset, such that fewer DQO failures were observed in 2020 (Tables C-8 and C-9). The differences between TN and TDN, and between TKN and DKN, exceeded the DQO of 20% in 12 and 14 samples (out of 184 samples), or 6.5% and 7.6% of samples, respectively. The affected samples were collected during both the ice-cover and open-water seasons on a variety of sampling days, and thus DQO failures appeared to be sporadic and random. Overall, the low frequency of DQO failures indicate that the data quality was acceptable.

In concert with the QC results of field duplicates, some results were removed from the dataset per the following rationale:

- The reported TDP value of 11.9 µg-P/L for MF3-5-5 collected during the open-water season was higher than its corresponding TP value of <2 µg-P/L and thus failed the DQO with an RPD of 169%. This reported TDP value was also higher than its duplicate of <2 µg-P/L (failing the DQO for field duplicate results). This TDP value was, therefore, not considered representative of this station.
- The reported TN and TKN value of <20 µg-N/L for MF3-7T-5 collected during the ice-cover season was lower than their corresponding TDN and DKN values of 130 µg-N/L and thus failed the DQO with an RPD of 171%. These reported TN and TKN values were also lower than their duplicates and inconsistent with concentrations measured at other depths. These TN and TKN values were, therefore, not considered representative of this station.
- The reported TDN and DKN values of 13,000 µg-N/L for NF1-5 collected during the open-water season were much higher than their corresponding TN and TKN values (TN = 220 µg-N/L, TKN = 170 µg-N/L) and thus failed the DQO with RPDs of 192 to 193%. These reported TDN and DKN values were also higher than their duplicates and inconsistent with concentrations measured at nearby stations. These TDN and DKN values were, therefore, not considered representative of this station.

One result failed the DQO, but was not removed from the dataset based solely on the QC results:

- The reported DKN value of 310 µg-N/L for FF2-5-4 collected during the open-water season was higher than the TKN value of 170 µg-N/L and thus failed the DQO with an RPD of 58%. This reported DKN value was also higher than its duplicate of 170 µg-N/L with an RPD of 58%. It was retained in the dataset, but was later identified as an anomalous value during screening (Attachment B).

Table C-7 Comparison of Total and Dissolved Phosphorus Concentrations, 2020

Season	Sample Name	Sampling Date	DL (µg-P/L)	Total Phosphorus (µg-P/L)	Total Dissolved Phosphorus (µg-P/L)	Relative Percent Difference (%)	>5 × DL?	QC Fail?
IC	NF5T-4	01-May-20	2	<2	2.1	71	N	N
IC	MF1-3T-4	21-Apr-20	2	2.3	2.4	4	N	N
IC	NF2B-5	21-Apr-20	2	2.3	6.0	89	N	N
IC	NF2M-4	21-Apr-20	2	3.2	6.4	67	N	N
IC	MF1-5M-4	22-Apr-20	2	<2	3.2	105	N	N
IC	LDG-48-5	25-Apr-20	2	2.2	3.2	37	N	N
OW	MF3-5-5	21-Aug-20	2	<2	11.9(a)	169	Y	Y

Notes: Only cases where the total dissolved phosphorus was greater than total phosphorus are presented in this table.

Results were evaluated using the criterion of relative percent difference (RPD) greater than 20%, where concentrations in one or both of the duplicate samples were greater than or equal to five times the corresponding DL.

a) Value removed from dataset as a result of data QAQC; see also section on nutrient duplicates.

µg-P/L = micrograms phosphorus per litre; DL = detection limit; QC = quality control; IC = ice-cover; OW = open-water; NF = near-field; MF = mid-field; LDG-48 = Lac de Gras outlet; N = no; Y = yes.

Table C-8 Comparison of Total and Dissolved Nitrogen Concentrations, 2020

Season	Sample Name	Sampling Date	DL (µg-N/L)	Total Nitrogen (µg-N/L)	Total Dissolved Nitrogen (µg-N/L)	Relative Percent Difference (%)	>5 × DL?	QC Fail?
IC	MF1-1M-4	21-Apr-20	20	250	280	11	Y	N
IC	FF1-2M-4	22-Apr-20	20	150	190	24	Y	Y
IC	FF1-2M-5	22-Apr-20	20	160	190	17	Y	N
IC	MF1-5B-5	22-Apr-20	20	230	260	12	Y	N
IC	MF1-5M-4	22-Apr-20	20	200	230	14	Y	N
IC	MF1-5M-5	22-Apr-20	20	170	230	30	Y	Y
IC	MF1-5T-4	22-Apr-20	20	180	190	5	Y	N
IC	MF1-5T-5	22-Apr-20	20	150	250	50	Y	Y
IC	FFD-1M-5	23-Apr-20	20	200	220	10	Y	N
IC	MF3-7B-4	23-Apr-20	20	160	170	6	Y	N
IC	MF3-7T-5	23-Apr-20	20	<20(a)	130	171	Y	Y
IC	MF3-3T-4	25-Apr-20	20	160	210	27	Y	Y
IC	MF3-3T-5	25-Apr-20	20	170	200	16	Y	N
IC	MF3-5B-5	26-Apr-20	20	200	220	10	Y	N
IC	MF2-1B-4	27-Apr-20	20	350	370	6	Y	N
IC	MF2-1B-5	27-Apr-20	20	350	380	8	Y	N
IC	MF2-1M-4	27-Apr-20	20	290	320	10	Y	N

Table C-8 Comparison of Total and Dissolved Nitrogen Concentrations, 2020 (continued)

Season	Sample Name	Sampling Date	DL (µg-N/L)	Total Nitrogen (µg-N/L)	Total Dissolved Nitrogen (µg-N/L)	Relative Percent Difference (%)	>5 × DL?	QC Fail?
IC	MF2-1M-5	27-Apr-20	20	250	290	15	Y	N
IC	MF2-1T-4	27-Apr-20	20	240	250	4	Y	N
IC	MF2-1T-5	27-Apr-20	20	240	250	4	Y	N
IC	MF3-1B-4	27-Apr-20	20	280	320	13	Y	N
IC	MF3-1B-5	27-Apr-20	20	260	310	18	Y	N
IC	MF3-1M-4	27-Apr-20	20	230	270	16	Y	N
IC	MF3-1M-5	27-Apr-20	20	220	240	9	Y	N
IC	MF3-1T-4	27-Apr-20	20	190	240	23	Y	Y
IC	MF3-1T-5	27-Apr-20	20	200	250	22	Y	Y
IC	MF3-2B-5	27-Apr-20	20	220	230	4	Y	N
IC	NF4B-4	28-Apr-20	20	350	370	6	Y	N
OW	NF1-5	07-Sep-20	20	280	13000(a)	192	Y	Y
OW	NF2-4	07-Sep-20	20	210	240	13	Y	N
OW	NF2-5	07-Sep-20	20	190	220	15	Y	N
OW	NF3-5	07-Sep-20	20	240	270	12	Y	N
OW	LDG48-5	16-Aug-20	20	120	130	8	Y	N
OW	LDS-4-4	16-Aug-20	20	140	150	7	Y	N
OW	FF1-2-4	18-Aug-20	20	120	180	40	Y	Y
OW	FF1-2-5	18-Aug-20	20	150	210	33	Y	Y
OW	MF3-7-4	21-Aug-20	20	110	130	17	Y	N
OW	MF3-7-5	21-Aug-20	20	110	180	48	Y	Y
OW	MF3-3-3-4	22-Aug-20	20	<20	41	122	N	N
OW	MF3-3-3-5	22-Aug-20	20	<20	60	143	N	N
OW	MF3-4-5	22-Aug-20	20	110	180	48	Y	Y
OW	MF2-3-4	28-Aug-20	20	170	200	16	Y	N
OW	MF2-3-5	28-Aug-20	20	160	190	17	Y	N
OW	MF3-1-5	28-Aug-20	20	160	170	6	Y	N
OW	MF1-1-4	31-Aug-20	20	180	190	5	Y	N

Notes: Only cases where the total dissolved nitrogen was greater than the total nitrogen are presented in this table. “Y” in “QC Fail?” column indicates a QC flag for relative percent difference (RPD) values that were greater than 20%, where concentrations in one or both of the duplicate samples were greater than or equal to five times the corresponding DL.

a) Value removed from dataset as a result of data QAQC; see also section on nutrient duplicates.

µg-N/L = micrograms nitrogen per litre; DL = detection limit; QC = quality control; IC = ice-cover; OW = open-water; NF = near-field; MF = mid-field; FF = far-field; N = no; Y = yes; LDG-48 = Lac de Gras outlet; LDS-4 = Lac du Sauvage Outlet (the Narrows).

Table C-9 Comparison of Total and Dissolved Kjeldahl Nitrogen Concentrations, 2020

Season	Sample Name	Sampling Date	DL (µg-N/L)	Total Kjeldahl Nitrogen (µg-N/L)	Dissolved Kjeldahl Nitrogen (µg-N/L)	Relative Percent Difference (%)	>5 × DL?	QC Fail?
IC	MF1-1M-4	21-Apr-20	20	190	210	10	Y	N
IC	FF1-2M-4	22-Apr-20	20	150	180	18	Y	N
IC	FF1-2M-5	22-Apr-20	20	160	190	17	Y	N
IC	MF1-5B-5	22-Apr-20	20	170	200	16	Y	N
IC	MF1-5M-4	22-Apr-20	20	180	210	15	Y	N
IC	MF1-5M-5	22-Apr-20	20	150	200	29	Y	Y
IC	MF1-5T-4	22-Apr-20	20	180	190	5	Y	N
IC	MF1-5T-5	22-Apr-20	20	150	250	50	Y	Y
IC	FFD-1M-5	23-Apr-20	20	150	170	13	Y	N
IC	MF3-7B-4	23-Apr-20	20	140	150	7	Y	N
IC	MF3-7T-5	23-Apr-20	20	<20	130	171	Y	Y
IC	MF3-3T-4	25-Apr-20	20	150	200	29	Y	Y
IC	MF3-3T-5	25-Apr-20	20	160	190	17	Y	N
IC	MF3-5B-5	26-Apr-20	20	150	170	13	Y	N
IC	MF2-1B-4	27-Apr-20	20	210	230	9	Y	N
IC	MF2-1B-5	27-Apr-20	20	190	220	15	Y	N
IC	MF2-1M-4	27-Apr-20	20	190	220	15	Y	N
IC	MF2-1M-5	27-Apr-20	20	170	210	21	Y	Y
IC	MF2-1T-4	27-Apr-20	20	220	240	9	Y	N
IC	MF2-1T-5	27-Apr-20	20	230	240	4	Y	N
IC	MF3-1B-4	27-Apr-20	20	180	220	20	Y	N
IC	MF3-1B-5	27-Apr-20	20	170	220	26	Y	Y
IC	MF3-1M-4	27-Apr-20	20	190	230	19	Y	N
IC	MF3-1M-5	27-Apr-20	20	170	180	6	Y	N
IC	MF3-1T-4	27-Apr-20	20	180	230	24	Y	Y
IC	MF3-1T-5	27-Apr-20	20	180	230	24	Y	Y
IC	MF3-2B-5	27-Apr-20	20	160	170	6	Y	N
IC	MF3-2T-4	27-Apr-20	20	160	170	6	Y	N
IC	NF4B-4	28-Apr-20	20	160	180	12	Y	N
OW	NF1-5	07-Sep-20	20	220	13000[(a)]	193	Y	Y
OW	NF2-4	07-Sep-20	20	160	190	17	Y	N
OW	NF2-5	07-Sep-20	20	140	170	19	Y	N
OW	NF3-5	07-Sep-20	20	190	210	10	Y	N
OW	LDG48-5	16-Aug-20	20	120	130	8	Y	N
OW	LDS-4-4	16-Aug-20	20	140	150	7	Y	N

Table C-9 Comparison of Total and Dissolved Kjeldahl Nitrogen Concentrations, 2020 (continued)

Season	Sample Name	Sampling Date	DL (µg-N/L)	Total Kjeldahl Nitrogen (µg-N/L)	Dissolved Kjeldahl Nitrogen (µg-N/L)	Relative Percent Difference (%)	>5 × DL?	QC Fail?
OW	FF1-2-4	18-Aug-20	20	120	180	40	Y	Y
OW	FF1-2-5	18-Aug-20	20	150	210	33	Y	Y
OW	FF2-5-4	19-Aug-20	20	170	310(b)	58	Y	Y
OW	FF2-5-5	19-Aug-20	20	150	170	13	Y	N
OW	MF3-7-4	21-Aug-20	20	110	130	17	Y	N
OW	MF3-7-5	21-Aug-20	20	110	180	48	Y	Y
OW	MF3-3-3-4	22-Aug-20	20	<20	41	122	N	N
OW	MF3-3-3-5	22-Aug-20	20	<20	60	143	N	N
OW	MF3-4-5	22-Aug-20	20	110	180	48	Y	Y
OW	MF2-3-4	28-Aug-20	20	150	180	18	Y	N
OW	MF2-3-5	28-Aug-20	20	150	170	13	Y	N
OW	MF3-1-5	28-Aug-20	20	150	160	6	Y	N
OW	MF1-1-4	31-Aug-20	20	150	160	6	Y	N

Notes: Only cases where the total dissolved Kjeldahl nitrogen was greater than the total Kjeldahl nitrogen are presented in this table. "Y" in "QC Fail?" column indicates a QC flag for relative percent difference (RPD) values that were greater than 20%, where concentrations in one or both of the duplicate samples were greater than or equal to five times the corresponding DL.

a) Value removed from dataset as a result of data QAQC; see also section on nutrient duplicates.

b) Value identified as an anomalous value in screening (Attachment B).

µg-N/L = micrograms nitrogen per litre; DL = detection limit; QC = quality control; IC = ice-cover; OW = open-water; NF = near-field; MF = mid-field; FF = far-field; N = no; Y = yes; LDG-48 = Lac de Gras outlet; LDS-4 = Lac du Sauvage Outlet (the Narrows).

Chlorophyll a Duplicate Samples

One of the 23 pairs of chlorophyll *a* duplicate samples exceeded the DQO of less than 40% RPD, while having concentrations greater than five times the DL in at least one of the samples (Table C-10). Overall, 4% of the duplicate pairs were notably different from one another; therefore, the analytical precision for the chlorophyll *a* samples was rated as high.

Table C-10 Summary of Duplicate Sample Results for Chlorophyll *a,* 2020

Season	Station	DL (µg/L)	Result 1 (µg/L)	Result 2 (µg/L)	Relative Percent Difference (%)	>5 x DL?	QC Fail?
OW	FF1-2	0.04	0.53	0.71	29	Y	N
OW	FF2-2	0.04	1.13	1.16	3	Y	N
OW	FF2-5	0.04	1.21	1.32	9	Y	N
OW	FFD-1	0.04	0.47	0.67	35	Y	N
OW	LDG-48	0.04	0.49	0.47	4	Y	N
OW	LDS-4	0.04	1.05	1.20	13	Y	N
OW	MF1-1	0.04	1.62	1.67	3	Y	N
OW	MF1-3	0.04	1.97	2.11	7	Y	N
OW	MF1-5	0.04	0.82	0.99	19	Y	N
OW	MF2-1	0.04	1.38	0.97	35	Y	N
OW	MF2-3	0.04	1.60	1.56	3	Y	N
OW	MF3-1	0.04	1.07	1.29	19	Y	N
OW	MF3-2	0.04	1.21	1.00	19	Y	N
OW	MF3-3	0.04	1.10	1.06	4	Y	N
OW	MF3-4	0.04	0.82	0.95	15	Y	N
OW	MF3-5	0.04	0.25	0.48	63	Y	Y
OW	MF3-6	0.04	0.63	0.60	5	Y	N
OW	MF3-7	0.04	0.58	0.59	2	Y	N
OW	NF1	0.04	1.23	1.72	33	Y	N
OW	NF2	0.04	1.64	1.73	5	Y	N
OW	NF3	0.04	1.43	1.72	18	Y	N
OW	NF4	0.04	1.37	1.10	22	Y	N
OW	NF5	0.04	1.51	1.37	10	Y	N

Note: “Y” in “QC Fail?” column indicates a QC flag for relative percent difference (RPD) values that were greater than 40%, where concentrations in one or both of the duplicate samples were greater than or equal to five times the corresponding DL.

µg/L = micrograms per litre; DL = detection limit; > = greater than; × = times; QC = quality control; OW = open-water; NF = near-field; MF = mid-field; FF = far-field; LDG-48 = Lac de Gras outlet; LDS-4 = Lac du Sauvage Outlet (the Narrows); N = no; Y = yes.

Zooplankton Biomass (as AFDM) Duplicate Samples

None of the zooplankton biomass duplicate samples exceeded the DQO of less than 40% RPD (Table C-11). The greater than 5× the DL criterion does not apply to zooplankton biomass because the DL is undefined. Since less than 10% of the duplicate pairs were notably different from one another, the analytical precision for the zooplankton biomass samples was rated as high.

Table C-11 Summary of Duplicate Sample Results for Zooplankton Biomass as Ash-Free Dry Mass, 2020

Season	Station	Result 1 (mg/m^3)	Result 2 (mg/m^3)	Relative Percent Difference (%)	QC Fail?
OW	FF1-2	45.55	48.78	6.8	N
OW	FF2-2	84.31	83.74	<1	N
OW	FF2-5	73.81	83.96	13	N
OW	FFD-1	40.72	42.68	5	N
OW	MF1-1	112.40	117.78	5	N
OW	MF1-3	88.31	109.60	22	N
OW	MF1-5	59.39	75.71	24	N
OW	MF2-1	80.36	68.10	17	N
OW	MF2-3	101.22	116.41	14	N
OW	MF3-1	61.12	51.45	17	N
OW	MF3-2	47.70	48.35	1	N
OW	MF3-3	67.55	64.41	5	N
OW	MF3-4	67.18	68.90	3	N
OW	MF3-5	27.21	30.89	13	N
OW	MF3-6	43.41	54.81	23	N
OW	MF3-7	35.27	41.17	15	N
OW	NF1	87.88	86.04	2	N
OW	NF2	54.70	60.74	10	N
OW	NF3	75.22	82.97	10	N
OW	NF4	134.79	150.01	11	N
OW	NF5	90.81	89.29	2	N

Note: “Y” in “QC Fail?” column indicates a QC flag for relative percent difference (RPD) values that were greater than 40%.

mg/m^3 = milligrams per cubic metre; QC = quality control; OW = open-water; NF = near-field; MF = mid-field; FF = far-field; N = no; Y = yes; - = not applicable.

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ATTACHMENT D

PERCENT CHANGE FROM BASELINE AND PREVIOUS YEAR

Percent Change from Baseline and Previous Year

Tables D-1 to D-10 provide percent change values for each eutrophication indicator from the baseline median and the previous year (i.e., 2019) median value, by area (i.e., NF, MF1, MF2, MF3, and LDG-48) and season (i.e., ice-cover and open-water) as required by Directive 2B from the WLWB review of the *2017 AEMP Annual Report*.

The results indicate that median values of eutrophication indicators have generally increased in the NF area relative to baseline (Table D-1 and Table D-6), consistent with EA predictions and interpretation of AEMP data during annual reporting. Further discussion of these results is provided below.

In the NF area, the eutrophication indicator that has the greatest percent difference since baseline during the ice-cover season is nitrate (Table D-1). The greatest increase relative to baseline was measured in the bottom depth samples (Table D-1), reflecting the discharge of effluent to this area and the likely position of the effluent plume in the water column. Large percent changes from baseline in nitrate and other nitrogen species were observed across all three MF areas, with decreasing median concentrations with distance from diffuser (Table D-2, Table D-3, and Table D-4), which is consistent with the results discussed in Section 3.

During the open-water season, nitrate + nitrite had the greatest percent increase in the NF (Table D-6). Increased median nitrate + nitrite concentrations relative to baseline were also observed in the MF areas during the open-water season (Table D-7 to Table D-9). Although a statistical gradient analysis of nitrate + nitrate concentrations during the open-water season could not be performed due to low detection frequency (Section 3.2.5.2), a visual evaluation showed shallow decreasing concentration gradients along each MF transect, which is consistent with the results in Tables D-7 to D-9.

The percent change from baseline was greater than observed in the NF area for MF3 nitrite concentrations during the ice-cover season, MF1 chlorophyll *a* and zooplankton biomass during the open-water season, and MF1 and MF2 total ammonia concentrations during the open-water season.

Percent changes from the previous year (i.e., 2019) in nitrogen variables were more variable, consisting of positive and negative values at varying magnitudes for all areas and both seasons, and reflect the general finding of year-to-year variability. In the NF area, 2020 nitrite concentrations had the greatest increase from the previous year during the ice-cover season, while phytoplankton biomass had the greatest increase during the open-water season.

The median concentrations of TP and TDP either decreased or did not change in 2020 relative to baseline in all sampling areas, and TDP either decreased or did not change in 2020 relative to 2019 medians. However, the percent change relative to previous year medians for TP increased in all MF areas during the ice-cover season, and in the NF and MF1 areas during the open-water season. The median concentration of SRP in the NF area during the ice-cover season was higher than baseline in 2020 (Table D-1). The median concentrations of SRP in all other areas during both seasons either decreased or did not change relative to baseline and the previous year.

Concentrations of chlorophyll *a,* phytoplankton, and zooplankton increased relative to baseline and the previous year in all areas during the open-water season of 2020 (Tables D-6 to D-10).

Table D-1 Percent Change from Baseline and Previous Year Data in the Near-field (NF) Area for Eutrophication Indicators during the Ice-cover Season in 2020

Variable	Unit	Baseline Median(b)	Previous Year Median			Current Year Median			% Change from Baseline			% Change from Previous Year		
			Top	Mid	Bottom	Top	Mid	Bottom	Top	Mid	Bottom	Top	Mid	Bottom
Nutrients														
Total phosphorus	µg-P/L	3.6	2.9	2.5	1.6	1.7	1.5	1.0	-54%	-58%	-72%	-42%	-40%	-38%
Total dissolved phosphorus	µg-P/L	2.0	1.0	1.0	1.0	1.0	1.0	1.0	-50%	-50%	-50%	0%	0%	0%
Soluble reactive phosphorus(a)	µg-P/L	0.5	1.3	1.7	1.3	0.9	0.9	1.0	80%	80%	100%	-28%	-45%	-20%
Total nitrogen	µg-N/L	152	252	372	332	245	340	395	62%	124%	161%	-3%	-8%	19%
Total dissolved nitrogen	µg-N/L	143	210	305	280	230	285	325	61%	99%	127%	10%	-6%	16%
Total Kjeldahl nitrogen	µg-N/L	-	238	227	186	205	210	215	-	-	-	-14%	-7%	16%
Dissolved Kjeldahl nitrogen	µg-N/L	-	196	160	149	190	170	165	-	-	-	-3%	7%	11%
Total ammonia - ALS	µg-N/L	14	22	40	31	24	26	35	68%	85%	148%	5%	-35%	13%
Nitrate	µg-N/L	3.4	14	145	137	35	120	160	929%	3,429%	4,606%	145%	-17%	17%
Nitrite(a)	µg-N/L	1.0	0.8	0.5	0.5	0.9	1.8	1.8	-10%	80%	80%	13%	260%	260%
Nitrate + nitrite	µg-N/L	6.5	14	145	137	42	125	160	538%	1,823%	2,362%	190%	-14%	17%
Soluble reactive silica	µg/L	-	50	736	650	120	402	937	-	-	-	142%	-45%	44%

Notes:

Values below detection limit were substituted with one half the detection limit prior to median calculations.

% Change from Baseline = (Current Year Median - Baseline Median) / Baseline Median; % Change from Previous Year = (Current Year Median - Previous Year Median) / Previous Year Median. Percentages presented in this table were calculated before rounding of data for consistent presentation; therefore, recalculation may not yield the exact percentages shown.

(a) Baseline Median was listed as less than the detection limit in the *AEMP Reference Conditions Report Version 1.4* (Golder 2019a), so the value was substituted with one half the detection limit for the purposes of calculating percent change. Value presented is the substituted value.

(b) Source: *AEMP Reference Conditions Report Version 1.4* (Golder 2019a).

BV Labs = Bureau Veritas Laboratories; µg-P/L = micrograms phosphorus per litre; µg-N/L = micrograms nitrogen per litre; µg/L = micrograms per litre; % = percent; - = not applicable.

Table D-2 Percent Change from Baseline and Previous Year Data in the Mid-field (MF1) Area for Eutrophication Indicators during the Ice-cover Season in 2020

Variable	Unit	Baseline Median[(b)]	Previous Year Median	Current Year Median	% Change from Baseline	% Change from Previous Year
Nutrients						
Total phosphorus	µg-P/L	3.6	1.0	2.3	-38%	125%
Total dissolved phosphorus	µg-P/L	2.0	1.0	1.0	-50%	0%
Soluble reactive phosphorus(a)	µg-P/L	0.5	0.9	0.5	0%	-44%
Total nitrogen	µg-N/L	152	234	250	65%	7%
Total dissolved nitrogen	µg-N/L	143	196	230	61%	17%
Total Kjeldahl nitrogen	µg-N/L	-	187	185	-	-1%
Dissolved Kjeldahl nitrogen	µg-N/L	-	165	175	-	6%
Total ammonia - ALS	µg-N/L	14	19	24	69%	22%
Nitrate	µg-N/L	3.4	23	62	1,724%	176%
Nitrite(a)	µg-N/L	1.0	0.9	1.4	40%	56%
Nitrate + nitrite	µg-N/L	6.5	28	64	885%	133%
Soluble reactive silica	µg/L	-	111	163	-	47%

Notes:

Values below detection limit were substituted with one half the detection limit prior to median calculations.

% Change from Baseline = (Current Year Median - Baseline Median) / Baseline Median; % Change from Previous Year = (Current Year Median - Previous Year Median) / Previous Year Median. Percentages presented in this table were calculated before rounding of data for consistent presentation; therefore, recalculation may not yield the exact percentages shown.

(a) Baseline Median was listed as less than the detection limit in the *AEMP Reference Conditions Report Version 1.4* (Golder 2019a), so the value was substituted with one half the detection limit for the purposes of calculating percent change. Value presented is the substituted value.

(b) Source: *AEMP Reference Conditions Report Version 1.4* (Golder 2019a).

BV Labs = Bureau Veritas Laboratories; µg-P/L = micrograms phosphorus per litre; µg-N/L = micrograms nitrogen per litre; µg/L = micrograms per litre; % = percent; - = not applicable.

Table D-3 Percent Change from Baseline and Previous Year Data in the Mid-field 2 (MF2) Area for Eutrophication Indicators during the Ice-cover Season in 2020

Variable	Unit	Baseline Median[b]	Previous Year Median	Current Year Median	% Change from Baseline	% Change from Previous Year
Nutrients						
Total phosphorus	µg-P/L	3.6	1.0	1.4	-63%	35%
Total dissolved phosphorus	µg-P/L	2.0	1.0	1.0	-50%	0%
Soluble reactive phosphorus[a]	µg-P/L	0.5	0.5	0.5	0%	0%
Total nitrogen	µg-N/L	152	227	288	90%	27%
Total dissolved nitrogen	µg-N/L	143	191	250	75%	31%
Total Kjeldahl nitrogen	µg-N/L	-	183	220	-	21%
Dissolved Kjeldahl nitrogen	µg-N/L	-	141	200	-	42%
Total ammonia - ALS	µg-N/L	14	17	24	74%	41%
Nitrate	µg-N/L	3.4	43	59	1,635%	37%
Nitrite[a]	µg-N/L	1.0	1.4	0.7	-33%	-50%
Nitrate + nitrite	µg-N/L	6.5	47	60	827%	28%
Soluble reactive silica	µg/L	-	70	103	-	47%

Notes:

Values below detection limit were substituted with one half the detection limit prior to median calculations.

% Change from Baseline = (Current Year Median - Baseline Median) / Baseline Median; % Change from Previous Year = (Current Year Median - Previous Year Median) / Previous Year Median. Percentages presented in this table were calculated before rounding of data for consistent presentation; therefore, recalculation may not yield the exact percentages shown.

(a) Baseline Median was listed as less than the detection limit in the *AEMP Reference Conditions Report Version 1.4* (Golder 2019a), so the value was substituted with one half the detection limit for the purposes of calculating percent change. Value presented is the substituted value.

(b) Source: *AEMP Reference Conditions Report Version 1.4* (Golder 2019a).

BV Labs = Bureau Veritas Laboratories; µg-P/L = micrograms phosphorus per litre; µg-N/L = micrograms nitrogen per litre; µg/L = micrograms per litre; % = percent; - = not applicable.

Table D-4 Percent Change from Baseline and Previous Year Data in the Mid-field 3 (MF3) Area for Eutrophication Indicators during the Ice-cover Season in 2020

Variable	Unit	Baseline Median[(b)]	Previous Year Median	Current Year Median	% Change from Baseline	% Change from Previous Year
Nutrients						
Total phosphorus	µg-P/L	3.6	1.0	2.2	-39%	120%
Total dissolved phosphorus	µg-P/L	2.0	1.0	1.0	-50%	0%
Soluble reactive phosphorus(a)	µg-P/L	0.5	0.5	0.5	0%	0%
Total nitrogen	µg-N/L	152	205	185	22%	-10%
Total dissolved nitrogen	µg-N/L	143	170	180	26%	6%
Total Kjeldahl nitrogen	µg-N/L	-	180	175	-	-3%
Dissolved Kjeldahl nitrogen	µg-N/L	-	142	155	-	9%
Total ammonia - ALS	µg-N/L	14	18	19	38%	5%
Nitrate	µg-N/L	3.4	25	15	326%	-42%
Nitrite(a)	µg-N/L	1.0	0.8	2.5	150%	213%
Nitrate + nitrite	µg-N/L	6.5	27	15.5	138%	-43%
Soluble reactive silica	µg/L	-	66	99	-	51%

Notes:

Values below detection limit were substituted with one half the detection limit prior to median calculations.

% Change from Baseline = (Current Year Median - Baseline Median) / Baseline Median; % Change from Previous Year = (Current Year Median - Previous Year Median) / Previous Year Median. Percentages presented in this table were calculated before rounding of data for consistent presentation; therefore, recalculation may not yield the exact percentages shown.

(a) Baseline Median was listed as less than the detection limit in the *AEMP Reference Conditions Report Version 1.4* (Golder 2019a), so the value was substituted with one half the detection limit for the purposes of calculating percent change. Value presented is the substituted value.

(b) Source: *AEMP Reference Conditions Report Version 1.4* (Golder 2019a).

BV Labs = Bureau Veritas Laboratories; µg-P/L = micrograms phosphorus per litre; µg-N/L = micrograms nitrogen per litre; µg/L = micrograms per litre; % = percent; - = not applicable.

Table D-5 Percent Change from Baseline and Previous Year Data at LDG-48 for Eutrophication Indicators during the Ice-cover Season in 2020

Variable	Unit	Baseline Median[(b)]	Previous Year Median	Current Year Median	% Change from Baseline	% Change from Previous Year
Nutrients						
Total phosphorus	µg-P/L	3.6	1.0	2.2	-40%	115%
Total dissolved phosphorus	µg-P/L	2.0	1.0	2.1	5%	110%
Soluble reactive phosphorus(a)	µg-P/L	0.5	0.5	0.5	0%	0%
Total nitrogen	µg-N/L	152	117	215	42%	85%
Total dissolved nitrogen	µg-N/L	143	270	200	40%	-26%
Total Kjeldahl nitrogen	µg-N/L	-	110	215	-	95%
Dissolved Kjeldahl nitrogen	µg-N/L	-	265	200	-	-25%
Total ammonia - ALS	µg-N/L	14	14	16	15%	14%
Nitrate	µg-N/L	3.4	2.6	1.0	-71%	-61%
Nitrite(a)	µg-N/L	1.0	0.5	0.5	-50%	0%
Nitrate + nitrite	µg-N/L	6.5	2.1	1.0	-85%	-52%
Soluble reactive silica	µg/L	-	40	64	-	60%

Notes:

Values below detection limit were substituted with one half the detection limit prior to median calculations.

% Change from Baseline = (Current Year Median - Baseline Median) / Baseline Median; % Change from Previous Year = (Current Year Median - Previous Year Median) / Previous Year Median. Percentages presented in this table were calculated before rounding of data for consistent presentation; therefore, recalculation may not yield the exact percentages shown.

(a) Baseline Median was listed as less than the detection limit in the *AEMP Reference Conditions Report Version 1.4* (Golder 2019a), so the value was substituted with one half the detection limit for the purposes of calculating percent change. Value presented is the substituted value.

(b) Source: *AEMP Reference Conditions Report Version 1.4* (Golder 2019a).

LDG = Lac de Gras; BV Labs = Bureau Veritas Laboratories; µg-P/L = micrograms phosphorus per litre; µg-N/L = micrograms nitrogen per litre; µg/L = micrograms per litre; % = percent; - = not applicable.

Table D-6 Percent Change from Baseline and Previous Year Data in the Near-field (NF) Area for Eutrophication Indicators during the Open-water Season in 2020

Variable	Unit	Baseline Median[(b)]	Previous Year Median	Current Year Median	% Change from Baseline	% Change from Previous Year
Biomass Indicators						
Chlorophyll *a*	µg/L	0.47	0.74	1.48	214%	101%
Phytoplankton biomass as biovolume	mg/m^3	163	124	464	184%	273%
Zooplankton biomass as ash-free dry mass	mg/m^3	25	74	87	246%	18%
Nutrients						
Total phosphorus	µg-P/L	3.3	1.0	2.0	-41%	95%
Total dissolved phosphorus	µg-P/L	1.0	1.0	1.0	0%	0%
Soluble reactive phosphorus	µg-P/L	1.0	2.0	0.5	-50%	-75%
Total nitrogen	µg-N/L	138	285	225	63%	-21%
Total dissolved nitrogen	µg-N/L	119	240	220	85%	-8%
Total Kjeldahl nitrogen	µg-N/L	-	255	175	-	-31%
Dissolved Kjeldahl nitrogen	µg-N/L	-	205	160	-	-22%
Total ammonia - ALS(a)	µg-N/L	1.0	30	9	785%	-71%
Nitrate(a)	µg-N/L	1.0	34	50	4,850%	46%
Nitrite(a)	µg-N/L	1.0	1.5	2.6	155%	76%
Nitrate + nitrite(a)	µg-N/L	0.5	35	52	10,200%	47%
Soluble reactive silica	µg/L	-	60	163	-	171%

Notes:

% Change from Baseline = (Current Year Median - Baseline Median) / Baseline Median; % Change from Previous Year = (Current Year Median - Previous Year Median) / Previous Year Median. Percentages presented in this table were calculated before rounding of data for consistent presentation; therefore, recalculation may not yield the exact percentages shown.

(a) Baseline Median was listed as less than the detection limit in the *AEMP Reference Conditions Report Version 1.4* (Golder 2019a), so the value was substituted with one half the detection limit for the purposes of calculating percent change. Value presented is the substituted value.

(b) Source: *AEMP Reference Conditions Report Version 1.4* (Golder 2019a).

BV Labs = Bureau Veritas Laboratories; µg/L = micrograms per litre; mg/m^3 = milligrams per cubic metre; µg-P/L = micrograms phosphorus per litre; µg-N/L = micrograms nitrogen per litre; % = percent; - = not applicable.

Table D-7 Percent Change from Baseline and Previous Year Data in the Mid-field 1 (MF1) Area for Eutrophication Indicators during the Open-water Season in 2020

Variable	Unit	Baseline Median[(b)]	Previous Year Median	Current Year Median	% Change from Baseline	% Change from Previous Year
Biomass Indicators						
Chlorophyll *a*	µg/L	0.47	0.67	1.65	250%	147%
Phytoplankton biomass as biovolume	mg/m^3	163	249	353	116%	42%
Zooplankton biomass as ash-free dry mass	mg/m^3	25	74	99	294%	34%
Nutrients						
Total phosphorus	µg-P/L	3.3	1.6	2.1	-36%	31%
Total dissolved phosphorus	µg-P/L	1.0	1.0	1.0	0%	0%
Soluble reactive phosphorus	µg-P/L	1.0	2.1	0.5	-50%	-76%
Total nitrogen	µg-N/L	138	220	220	59%	0%
Total dissolved nitrogen	µg-N/L	119	210	140	18%	-33%
Total Kjeldahl nitrogen	µg-N/L	-	210	210	-	0%
Dissolved Kjeldahl nitrogen	µg-N/L	-	200	140	-	-30%
Total ammonia - ALS(a)	µg-N/L	1.0	43	10	880%	-77%
Nitrate(a)	µg-N/L	1.0	5.9	5.9	485%	0%
Nitrite(a)	µg-N/L	1.0	0.5	0.5	-50%	0%
Nitrate + nitrite(a)	µg-N/L	0.5	5.9	5.9	1,070%	0%
Soluble reactive silica	µg/L	-	37	118	-	223%

Notes:

Values below detection limit were substituted with one half the detection limit prior to median calculations.

% Change from Baseline = (Current Year Median - Baseline Median) / Baseline Median; % Change from Previous Year = (Current Year Median - Previous Year Median) / Previous Year Median. Percentages presented in this table were calculated before rounding of data for consistent presentation; therefore, recalculation may not yield the exact percentages shown.

(a) Baseline Median was listed as less than the detection limit in the *AEMP Reference Conditions Report Version 1.4* (Golder 2019a), so the value was substituted with one half the detection limit for the purposes of calculating percent change. Value presented is the substituted value.

(b) Source: *AEMP Reference Conditions Report Version 1.4* (Golder 2019a).

BV Labs = Bureau Veritas Laboratories; µg/L = micrograms per litre; mg/m^3 = milligrams per cubic metre; µg-P/L = micrograms phosphorus per litre; µg-N/L = micrograms nitrogen per litre; % = percent; - = not applicable.

Table D-8 Percent Change from Baseline and Previous Year Data in the Mid-field 2 (MF2) Area for Eutrophication Indicators during the Open-water Season in 2020

Variable	Unit	Baseline Median[(b)]	Previous Year Median	Current Year Median	% Change from Baseline	% Change from Previous Year
Biomass Indicators						
Chlorophyll *a*	µg/L	0.47	0.69	1.22	160%	76%
Phytoplankton biomass as biovolume	mg/m^3	163	140	229	40%	63%
Zooplankton biomass as ash-free dry mass	mg/m^3	25	73	81	225%	12%
Nutrients						
Total phosphorus	µg-P/L	3.3	1.6	1.8	-46%	9%
Total dissolved phosphorus	µg-P/L	1.0	1.0	1.0	0%	0%
Soluble reactive phosphorus	µg-P/L	1.0	2.2	0.5	-50%	-77%
Total nitrogen	µg-N/L	138	223	200	45%	-10%
Total dissolved nitrogen	µg-N/L	119	200	182.5	53%	-9%
Total Kjeldahl nitrogen	µg-N/L	-	213	170	-	-20%
Dissolved Kjeldahl nitrogen	µg-N/L	-	193	165	-	-14%
Total ammonia - ALS(a)	µg-N/L	1.0	23	12	1,093%	-47%
Nitrate(a)	µg-N/L	1.0	6.9	18.5	1,750%	168%
Nitrite(a)	µg-N/L	1.0	0.7	0.5	-50%	-23%
Nitrate + nitrite(a)	µg-N/L	0.5	7.5	19.0	3,700%	153%
Soluble reactive silica	µg/L	-	28	139	-	400%

Notes:

Values below detection limit were substituted with one half the detection limit prior to median calculations.

% Change from Baseline = (Current Year Median - Baseline Median) / Baseline Median; % Change from Previous Year = (Current Year Median - Previous Year Median) / Previous Year Median. Percentages presented in this table were calculated before rounding of data for consistent presentation; therefore, recalculation may not yield the exact percentages shown.

(a) Baseline Median was listed as less than the detection limit in the *AEMP Reference Conditions Report Version 1.4* (Golder 2019a), so the value was substituted with one half the detection limit for the purposes of calculating percent change. Value presented is the substituted value.

(b) Source: *AEMP Reference Conditions Report Version 1.4* (Golder 2019a).

BV Labs = Bureau Veritas Laboratories; µg/L = micrograms per litre; mg/m^3 = milligrams per cubic metre; µg-P/L = micrograms phosphorus per litre; µg-N/L = micrograms nitrogen per litre; % = percent; - = not applicable.

Table D-9 Percent Change from Baseline and Previous Year Data in the Mid-field 3 (MF3) Area for Eutrophication Indicators during the Open-water Season in 2020

Variable	Unit	Baseline Median[(b)]	Previous Year Median	Current Year Median	% Change from Baseline	% Change from Previous Year
Biomass Indicators						
Chlorophyll *a*	µg/L	0.47	0.35	0.89	88%	153%
Phytoplankton biomass as biovolume	mg/m^3	163	118	273	67%	132%
Zooplankton biomass as ash-free dry mass	mg/m^3	25	38	49	96%	28%
Nutrients						
Total phosphorus	µg-P/L	3.3	1.7	1.0	-70%	-39%
Total dissolved phosphorus	µg-P/L	1.0	1.0	1.0	0%	0%
Soluble reactive phosphorus	µg-P/L	1.0	1.3	0.5	-50%	-62%
Total nitrogen	µg-N/L	138	190	145	5%	-24%
Total dissolved nitrogen	µg-N/L	119	185	135	13%	-27%
Total Kjeldahl nitrogen	µg-N/L	-	190	145	-	-24%
Dissolved Kjeldahl nitrogen	µg-N/L	-	180	130	-	-28%
Total ammonia - ALS(a)	µg-N/L	1.0	23	8	720%	-65%
Nitrate(a)	µg-N/L	1.0	2.9	1.0	0%	-66%
Nitrite(a)	µg-N/L	1.0	0.5	0.5	-50%	0%
Nitrate + nitrite(a)	µg-N/L	0.5	3.0	1.1	120%	-63%
Soluble reactive silica	µg/L	-	41	79	-	93%

Notes:

Values below detection limit were substituted with one half the detection limit prior to median calculations.

% Change from Baseline = (Current Year Median - Baseline Median) / Baseline Median; % Change from Previous Year = (Current Year Median - Previous Year Median) / Previous Year Median. Percentages presented in this table were calculated before rounding of data for consistent presentation; therefore, recalculation may not yield the exact percentages shown.

(a) Baseline median was listed as less than the detection limit in the *AEMP Reference Conditions Report Version 1.4* (Golder 2019a), so the value was substituted with one half the detection limit for the purposes of calculating percent change. Value presented is the substituted value.

(b) Source: *AEMP Reference Conditions Report Version 1.4* (Golder 2019a).

BV Labs = Bureau Veritas Laboratories; µg/L = micrograms per litre; mg/m^3 = milligrams per cubic metre; µg-P/L = micrograms phosphorus per litre; µg-N/L = micrograms nitrogen per litre; % = percent; - = not applicable.

Table D-10 Percent Change from Baseline and Previous Year Data at LDG-48 for Eutrophication Indicators during the Open-water Season in 2020

Variable	Unit	Baseline Median[(b)]	Previous Year Median	Current Year Median	% Change from Baseline	% Change from Previous Year
Biomass Indicators						
Chlorophyll *a*	µg/L	0.47	0.06	0.48	2%	700%
Phytoplankton biomass as biovolume	mg/m³	163	-	183	-	-
Zooplankton biomass as ash-free dry mass	mg/m³	25	-	-	-	-
Nutrients						
Total phosphorus	µg-P/L	3.3	1.0	1.0	-70%	0%
Total dissolved phosphorus	µg-P/L	1.0	1.0	1.0	0%	0%
Soluble reactive phosphorus	µg-P/L	1.0	1.5	0.5	-50%	-67%
Total nitrogen	µg-N/L	138	190	125	-10%	-34%
Total dissolved nitrogen	µg-N/L	119	180	125	5%	-31%
Total Kjeldahl nitrogen	µg-N/L	-	190	125	-	-34%
Dissolved Kjeldahl nitrogen	µg-N/L	-	180	125	-	-31%
Total ammonia - ALS(a)	µg-N/L	1.0	30	2.5	150%	-92%
Nitrate(a)	µg-N/L	1.0	1.0	1.0	0%	0%
Nitrite(a)	µg-N/L	1.0	0.5	0.5	-50%	0%
Nitrate + nitrite(a)	µg-N/L	0.5	1.1	1.1	120%	0%
Soluble reactive silica	µg/L	-	174	136	-	-22%

Notes:

Values below detection limit were substituted with one half the detection limit prior to median calculations.

% Change from Baseline = (Current Year Median - Baseline Median) / Baseline Median; % Change from Previous Year = (Current Year Median - Previous Year Median) / Previous Year Median. Percentages presented in this table were calculated before rounding of data for consistent presentation; therefore, recalculation may not yield the exact percentages shown.

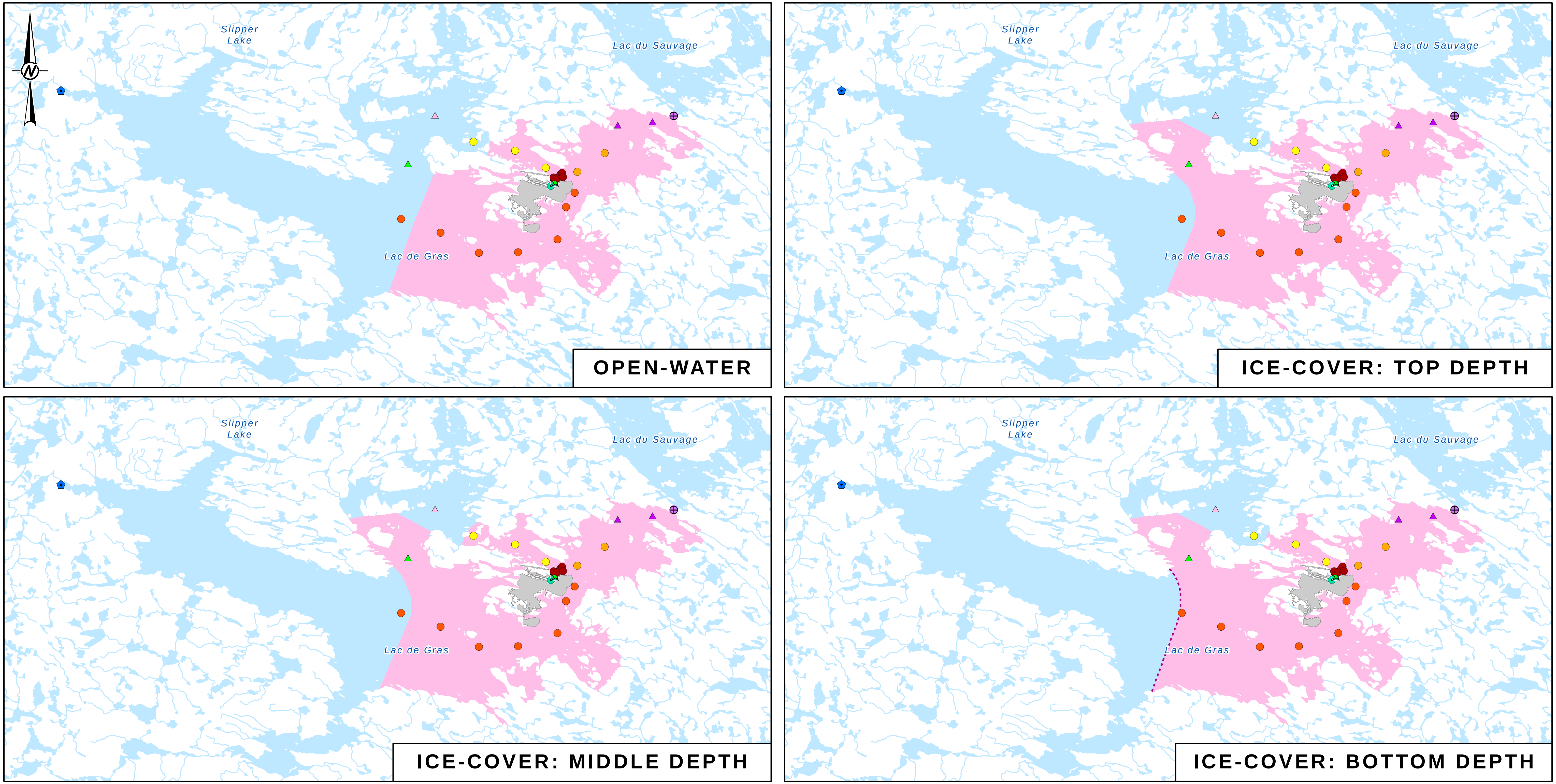
(a) Baseline median was listed as less than the detection limit in the *AEMP Reference Conditions Report Version 1.4* (Golder 2019a), so the value was substituted with one half the detection limit for the purposes of calculating percent change. Value presented is the substituted value.

(b) Source: *AEMP Reference Conditions Report Version 1.4* (Golder 2019a).

LDG = Lac de Gras; BV Labs = Bureau Veritas Laboratories; µg/L = micrograms per litre; mg/m³ = milligrams per cubic metre; µg-P/L = micrograms phosphorus per litre; µg-N/L = micrograms nitrogen per litre; % = percent; - = not applicable.

ATTACHMENT E

SUPPLEMENTAL EXTENT OF EFFECT FIGURES



LEGEND

- ★ DIFFUSERS
- ⊙ SURVEILLANCE NETWORK PROGRAM

STATION LOCATIONS

- △ FAR-FIELD 1
- ▲ FAR-FIELD 2
- ▲ FAR-FIELD D
- ⬟ LAC DE GRAS OUTLET
- ⊕ LAC DU SAUVAGE OUTLET
- ● MID-FIELD 1
- ● MID-FIELD 2
- ● MID-FIELD 3
- ● NEAR-FIELD

- ┅ UNCERTAIN EFFECT BOUNDARY
- ─ WATERCOURSE
- ▨ AFFECTED AREA
- ▨ DIAVIK FOOTPRINT
- ▨ WATERBODY

0 10 20
1:350,000 KILOMETRES

REFERENCE(S)
HYDROGRAPHY DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
PROJECTION: UTM ZONE 12 DATUM: NAD 83

CLIENT
RioTinto

PROJECT
DIAVIK DIAMOND MINES (2012) INC.

CONSULTANT
GOLDER

YYYY-MM-DD	2021-03-22
DESIGNED	MC
PREPARED	LMS
REVIEWED	MC
APPROVED	RLS

TITLE
TOTAL NITROGEN AFFECTED AREA IN LAC DE GRAS BY SEASON AND DEPTH, 2019

PROJECT NO.	PHASE	REV.	FIGURE
20136424	10000	0	E-1

ATTACHMENT F

ASSESSMENT OF TOTAL PHOSPHORUS DEPOSITION TO LAC DE GRAS

ASSESSMENT OF TOTAL PHOSPHORUS DEPOSITION TO LAC DE GRAS

Introduction

Lac de Gras is an oligotrophic lake characterized by very low concentrations of nutrients. Phosphorus is delivered naturally to Lac de Gras directly via atmospheric deposition and indirectly via runoff from the watershed. In the region of the Diavik Mine, the background rate of atmospheric deposition of phosphorus is typically small and rock weathering rates are slow. As a result, the aquatic ecosystem in Lac de Gras is expected to be phosphorus-limited, consistent with the findings of the AEMP. Land and aquatic retention and recycling rates of phosphorus in the region are largely unknown.

The *AEMP Design Plan Version 4.1* (Golder 2017) requires annual analysis of phosphorus loads from the Diavik Diamond Mine (Mine) and from other sources to Lac de Gras. The methods used to compute total phosphorus (TP) loads to Lac de Gras from relevant sources and a discussion of the results of the analysis are presented herein.

Methods

In addition to natural sources, Mine effluent and atmospheric deposition of phosphorus contained in Mine-related fugitive dust can contribute additional anthropogenic phosphorus to Lac de Gras. In this document, the relative magnitudes of phosphorus delivered to Lac de Gras in 2020 from the following sources are estimated:

- natural (i.e., background) atmospheric deposition of TP directly to Lac de Gras
- natural (i.e., background) atmospheric deposition of TP to the Lac de Gras watershed delivered indirectly through runoff to Lac de Gras
- anthropogenic TP delivered directly to Lac de Gras via the Mine effluent
- anthropogenic TP delivered directly to Lac de Gras via atmospheric deposition of fugitive dust
- anthropogenic TP delivered indirectly to Lac de Gras via atmospheric deposition of fugitive dust to the Lac de Gras watershed

Estimation of the above quantities used the same approach as described previously in the *2019 AEMP Annual Report* (Golder 2020a) and the *2017 to 2019 Aquatic Effects Re-evaluation Report* (Golder 2020b). The data used and methods implemented herein are summarized below:

- The 2020 dustfall monitoring program included three monitoring components: dustfall gauges, dustfall from snow surveys, and snow water chemistry from snow surveys (ERM 2021). Dustfall gauges were placed at 14 stations (including two control stations), which collected dustfall year-round. Dustfall snow surveys were performed at 27 stations (i.e., 24 monitoring stations and 3 reference stations referred to as “control stations”), along five transects around the Mine, on land and on the ice.
- Snow water chemistry was analyzed in snow core samples collected from 16 on-ice monitoring stations and 3 control stations. The TP concentrations (in mg/L) in snow data from the snow water chemistry samples were used in the analysis.

- Ancillary data collected with the snow cores enabled the conversion of concentration in snow water (in mg/L) to an areal deposition rate (in milligrams per square decimetre per year; mg/dm^2/yr). The formula used to perform the conversion was as follows:

  $$D = (C * V * 365)/(N * A * T)$$

  where:

  D = TP deposition rate (mg/dm^2/yr)

  C = concentration of TP in snow water (mg/L)

  V = snow water volume (L)

  N = number of snow cores

  A = area of snow core tube (0.2922 dm^2)

  T = number of exposure days

- The land-based snow sample exposure days were calculated as the days between the first snowfall date (05 October 2019) and the snow sample collection date at the land station. The over-water or “on-ice” snow sample exposure days were calculated as the days between the freeze-up date (28 October 2019) and the snow sample collection date at individual stations.
- The geometric mean of TP concentrations measured in samples collected at the control stations were used to calculate natural background TP deposition.
- The surface area of Lac de Gras (573 km^2) and the Lac de Gras watershed area (3,542 km^2) were multiplied by the background rates of TP deposition to estimate the magnitude of the TP load from natural atmospheric deposition to Lac de Gras and the watershed.
- Observed rates of anthropogenic TP deposition in 2020 were calculated using TP concentrations measured in snow samples in the dust monitoring program. The relationship between the wintertime TP deposition and the wintertime dust deposition was robust in 2020 (r^2 = 0.94).
- The observed TP deposition data at the on-ice snow stations and the calculated TP deposition data at the on-land snow sampling stations and dustfall gauges were then spatially interpolated using kriging, and integrated to estimate anthropogenic TP loads from fugitive Mine dust.
- The annual TP load from Mine effluent in 2020 was 289 kg.
- For the spatial interpolation of anthropogenic TP loading:
  - Spatial interpolation of the dust deposition data was carried out for a 105.7 km x 80 km domain centred on the Mine. The grid resolution inside the domain was set to 20 by 20 m, but excluded the area of the domain occupied by the Mine footprint.
  - There were 19 valid TP observations from snow survey transects in 2020 (N_{obs} = 19). TP deposition rates as a function of distance from the Mine centroid were evaluated for 2020. Spatial trends in TP deposition as a function of distance from the centroid were fit using a first-order decay function, whose goodness-of-fit was evaluated using the coefficient of determination (r^2) from the least-

squares regression. An r^2 larger than 0.5 indicates a robust fit of the dust deposition as a function of distance from the centroid.

- A TP deposition zone of influence (ZOI) was delineated by examining the distance from which the TP deposition would be reduced to the level of natural background.
- The observed and calculated areal deposition rates were excluded from the spatial interpolation when the stations were outside of the TP deposition ZOI or the TP deposition rates were less than the background TP deposition rate.
- Prior to spatial interpolation in QGIS, TP deposition rates at the edges of TP deposition ZOI were set equal to the background rate of TP deposition observed in 2020.
- Prior to spatial interpolation, the observed and calculated areal deposition rates were log-transformed to better capture the steep gradients observed in dust deposition as a function of distance from the Mine boundary. Mass loads (in tonnes/year [t/yr]) were calculated by integrating the spatially interpolated areal loads (mg/dm^2/yr) across the domain, and then back-transforming the results. This procedure is described by the following equation where the "sum of dust deposition data" represents the sum of the areal loads interpolated for each 20 by 20 m grid cell within the domain:

$$Mass\ Loading\ \left(\frac{t}{yr}\right) = sum\ of\ dust\ deposition\ data\ \left(\frac{mg}{dm^2 \cdot yr}\right) \times \frac{100\ dm^2}{m^2} \times 20\ m \times 20\ m\ \times\ \frac{t}{10^9\ mg}$$

- The "zonal statistics table" tool in QGIS was used to calculate 2020 mass loads for three separate regions. These three regions correspond to: (1) the Mine footprint (excluded from analysis); (2) Lac de Gras; and, (3) the Lac de Gras watershed excluding Lac de Gras. Total loads to the Lac de Gras watershed can be obtained by summing deposition to Lac de Gras and the Lac de Gras watershed.

The following assumptions were implicit to the analysis of TP loading to Lac de Gras and its watershed:

- Chemical weathering of local rocks is a potential source of TP to Lac de Gras; however, this weathering is typically slow and was not considered due to a lack of relevant data.
- TP deposition, as derived from TP concentrations measured in snow, is assumed to represent all TP deposition over the winter period.
- TP concentrations in snow water are a reasonable surrogate for TP concentrations in dustfall throughout the year. This also assumes weak dustfall seasonality and constant TP fraction in the dust. Analysis of seasonal trends of dust deposition from multiple years of dustfall monitoring at the Mine has indicated that dust deposition is lowest in the fall and similar in magnitude in the other three seasons (Golder 2020b).
- There are no seasonal differences in the source of TP in dust (i.e., TP concentrations in dust are similar between the open-water and ice-cover seasons).
- The control stations are unaffected by atmospheric deposition of fugitive Mine dust (i.e., they are assumed to be representative of the regional background rate of TP deposition).
- Atmospheric deposition of natural TP is spatially homogeneous throughout the Lac de Gras watershed (i.e., the mean/median background values are assumed to be valid and spatially representative).

- All atmospheric deposition of TP in the Lac de Gras watershed reports to Lac de Gras. This explicitly ignores uptake of TP on land, its storage, and eventual release. In other words, steady-state is assumed where the mass of TP deposited to the landscape is assumed to be in equilibrium with the mass of TP being delivered to the lake via runoff during a single calendar year.

Results

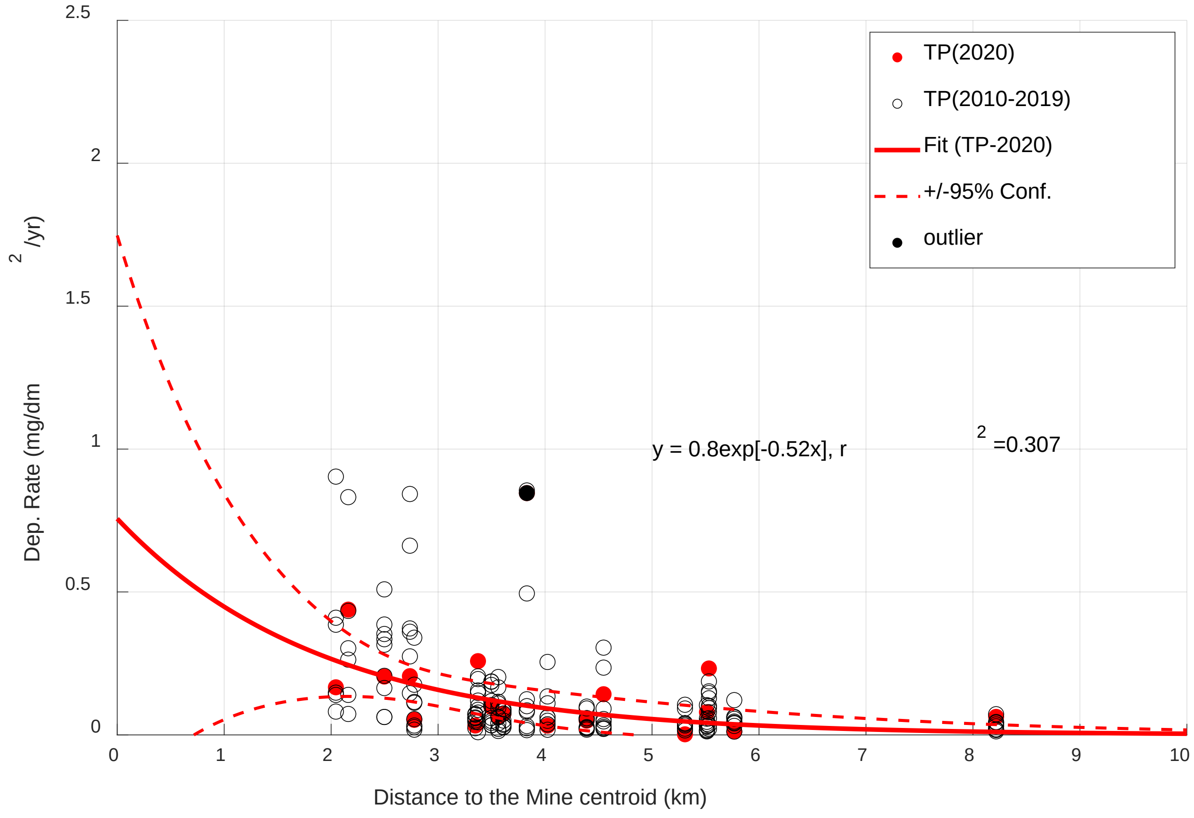
TP Deposition Rates

Figure F-1 shows TP deposition measured in 2020 as a function of distance from the Mine centroid. Also included in the figure are the data collected at the same locations from 2010 until 2019. Results of the fit to a first-order decay function for 2020 are plotted as a solid line, with the 95% confidence interval limits plotted as dashed lines. In 2020, snow sampling station SS5-3 at 3.8 km from the Mine centroid, observed an excessively high dust deposition rate (795.2 mg/dm^2/yr) and TP deposition rate (0.846 mg/dm^2/yr; identified by a black symbol in Figure F-1). This data point has been considered as outlier and excluded from the fitting to avoid skewing the results. The first order decay function did not result in a robust fit ($r^2 < 0.5$), which suggests there is spatial variability in dust deposition among the snow survey transects.

Table F-1 compares background TP deposition rate in 2020 with the historical background TP deposition rates. The re-evaluation report estimated TP background deposition rates for three time periods, i.e., 2010 to 2013, 2014 to 2016, and 2017 to 2019. The 2020 background TP deposition rate was comparable to the background deposition rate of the most recent time period (i.e., 2017 to 2019) (Table F-1).

The TP deposition zone of influence in 2020 was estimated to be approximately 5.0 km from the Mine centroid. This distance was consistent with the dust zone of influence (i.e., 4.8 km) for the 2017-2019 time period as estimated in the re-evaluation report.

Figure F-1 Total Phosphorus Deposition as a Function of Distance to the Diavik Mine Centroid



TP = total phosphorus; r^2 = coefficient of determination; mg/dm^2/yr = milligrams per square decimetre per year.

Table F-1 Background Total Phosphorus Deposition Rates in Snow from 2010 to 2020

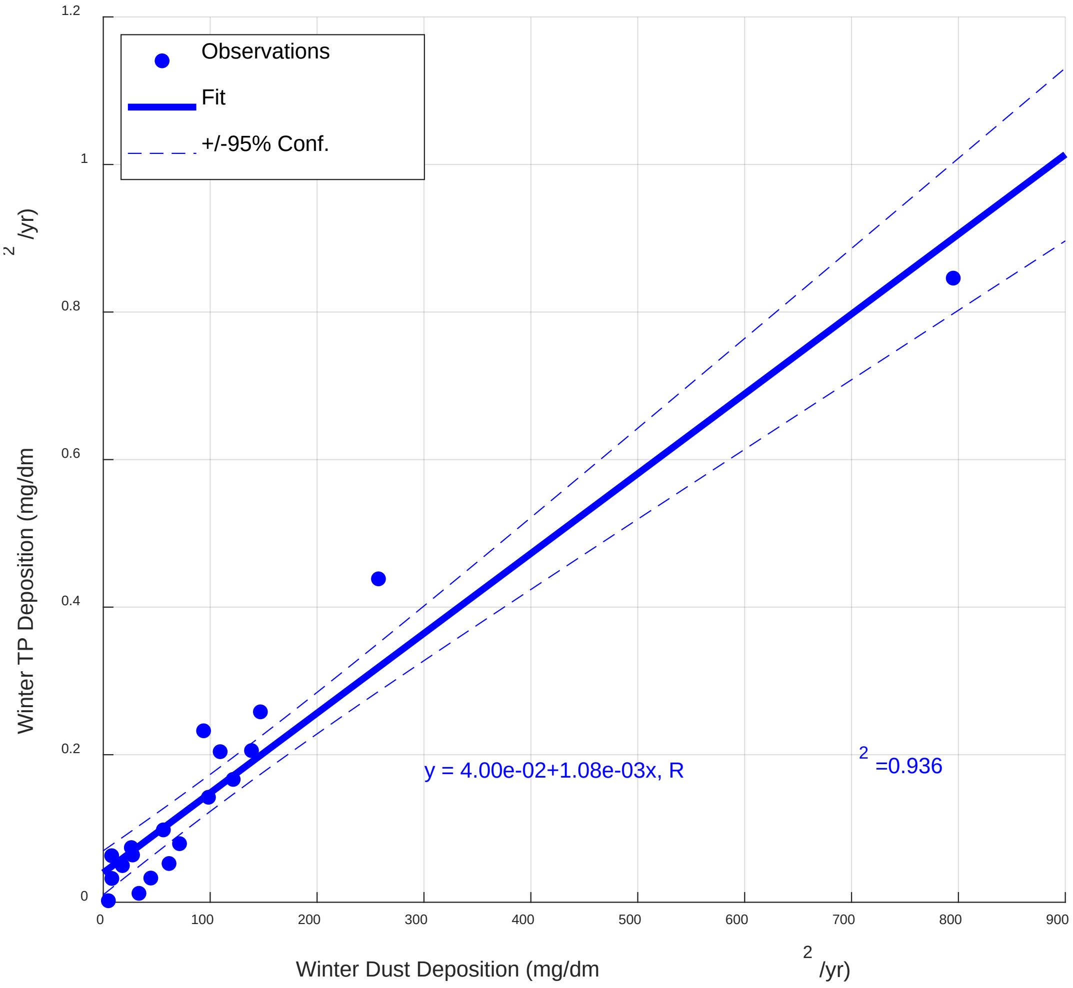
Year	Background TP Deposition (mg/dm^2/yr)
2020	0.056
2017-2019	0.051
2014-2016	0.044
2010-2013	0.037

mg/dm^2/yr = milligrams per square decimetre per year; TP = total phosphorus.

The determination of background versus Mine-related TP loading depends on spatial integration of TP deposition over a large area. Annual phosphorus deposition was estimated using the more numerous whole-year quarterly dust deposition data. This required employing Type-II linear regression of TP versus dust deposition from the snow sample data. The results of the 2020 regression are shown in Figure F-2.

This relationship was a very robust fit (r^2 = 0.936), supporting the hypothesis that TP was likely particulate-bound and being emitted as fugitive dust from the Mine. The robust fit also indicated the validity of using this relationship to calculate the TP dust deposition rates from dust deposition rates for the on-land snow sampling stations and dustfall gauge stations.

Figure F-2: Linear Regressions of Wintertime TP versus Dust Deposition



TP = total phosphorus; r^2 = coefficient of determination; mg/dm^2/yr = milligrams per square decimetre per year.

TP Loads

Natural TP loads to Lac de Gras, and to the Lac de Gras watershed excluding Lac de Gras, were computed using the geometric mean deposition rate from the control stations (0.056 mg/dm^2/yr). The direct natural TP load to the lake is estimated at 3.2 t/yr and the natural TP load to the watershed excluding the lake and Mine is 20 t/y, for a total watershed load of 23 t/yr (Table F-2). These natural TP loads were comparable to those estimated for the 2017 to 2019 period in the re-evaluation report.

The anthropogenic TP load from Mine effluent was 0.29 t/yr in 2020. Effluent is assumed to include TP captured in runoff collected on-site that may be affected by the local deposition of fugitive dust within the Mine footprint.

Results of the spatial interpolation of TP deposition around the Mine footprint for 2017 to 2019 in the re-evaluation report and for 2020 are illustrated in Figure F-3. Higher TP deposition rates were observed around the Mine in 2020 than the average TP deposition during 2017 to 2019, especially in the south of the Mine, indicating dust-borne TP emissions from activities around the A21 pit.

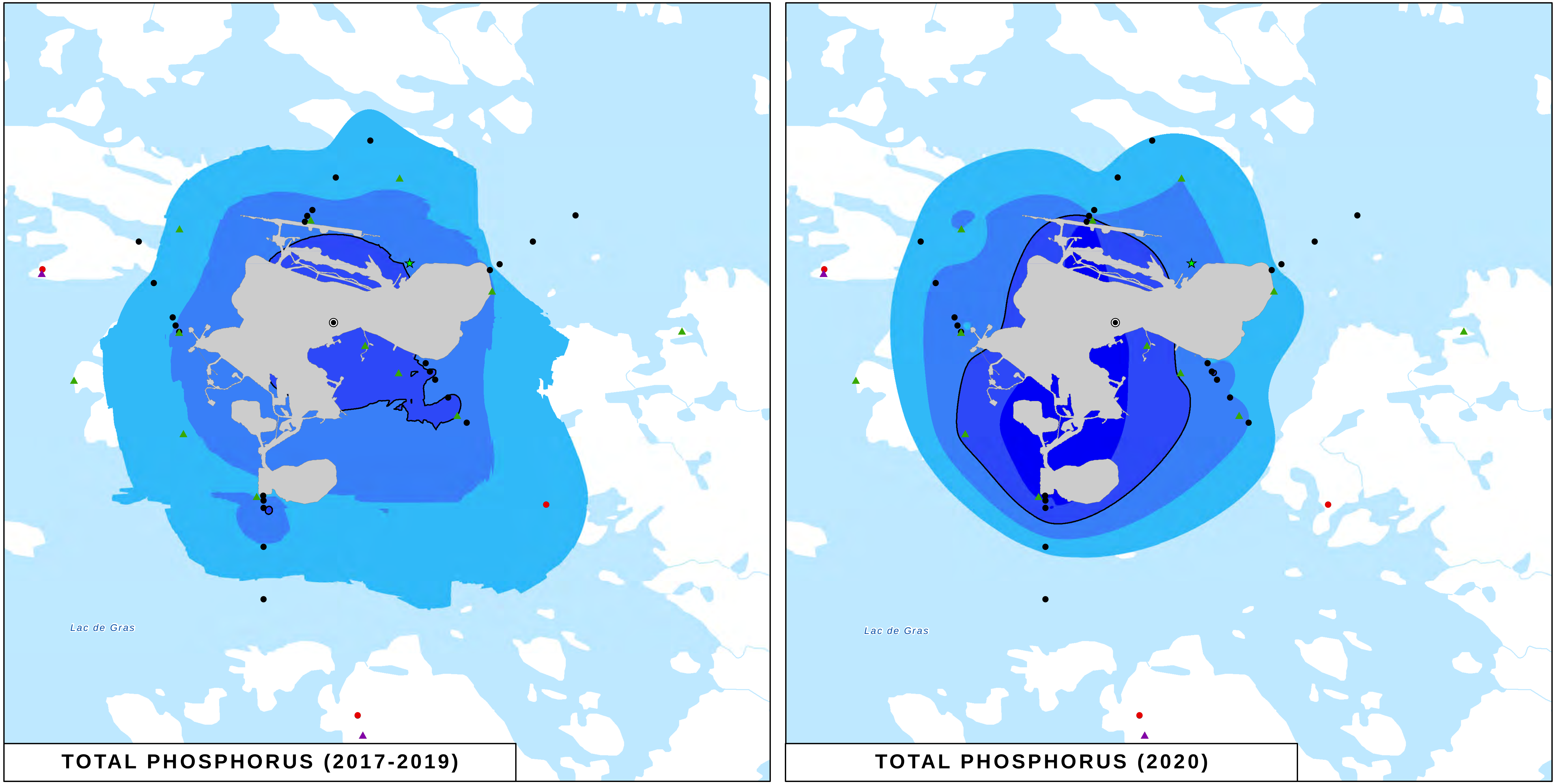
The anthropogenic TP loads were calculated by subtracting the natural background load from the total TP load. As summarized in Table F-2, the anthropogenic TP loads to Lac de Gras directly and to the watershed (excluding the Mine and lake) were 0.69 and 0.35 t/yr, respectively, for a total load (including Mine effluent) of 1.31 t in 2020. The anthropogenic TP loads to Lac de Gras and the watershed are consistent with the values estimated in the re-evaluation report for the 2017 to 2019 period. The contribution of anthropogenic TP loads to the total TP loads to the watershed, and eventually to the Lac de Gras, was 5.4%.

Table F-2 Summary of Total Annual Phosphorus Loads to Lac de Gras for 2017 to 2019, and 2020

Total Phosphorus Source		Area (km²)	2017 to 2019		2020	
			TP Load (t/yr)[(b)]	Percent contributing to the total TP load[(c)]	TP Load (t/yr)	Percent contributing to the total TP load
Natural Background TP	Deposition to Lac de Gras	573	2.9	13%	3.2	13%
	Deposition to watershed excluding lake	3,542	18	81%	20	81%
	Watershed Subtotal[(a)]	**4,115**	**21**	**94%**	**23**	**95%**
Anthropogenic TP	Diavik Mine effluent	n/a	0.36	1.6%	0.29	1.1%
	Deposition to Lac de Gras	573	0.65	2.9%	0.69	2.8%
	Deposition to watershed excluding lake and Mine footprint	3,530	0.33	1.5%	0.35	1.4%
	Watershed Subtotal[(a)]	**4,115**	**1.3**	**6.0%**	**1.3**	**5.4%**
Total[(a)]		**4,115**	**22**	N/A	**24**	N/A

(a) Values may not sum up to subtotal or total due to rounding.
(b) Diavik Mine Effluent was the average effluent in 2017 to 2019.
(c) Percentages estimated from TP loads in 2017 to 2019 assuming same Mine effluent as 2020.

N/A = not applicable; TP = total phosphorus; t/yr = tonnes per year.



LEGEND

★ DIFFUSERS
◉ DIAVIK FOOTPRINT CENTROID
— WATERCOURSE
▨ DIAVIK FOOTPRINT
▨ WATERBODY
▲ DUSTFALL GAUGE STATION
● SNOW SURVEY CONTROL STATION
● SNOW SURVEY STATION

— CONTOUR - 0.4 mg/dm^2/yr

TOTAL PHOSPHORUS - ANNUAL DEPOSITION RATE (mg/dm^2/yr)

☐ <0.1
▨ 0.1 - 0.2
▨ 0.2 - 0.4
▨ 0.4 - 0.8
▨ 0.8 - 1.6
▨ 1.6 - 3.2
▨ 3.2 - 6.4
▨ 6.4 - 11.5
▨ >11.5

0 2 4
1:75,000 KILOMETRES

REFERENCE(S)
HYDROGRAPHY DATA OBTAINED FROM GEOGRATIS, © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
PROJECTION: UTM ZONE 12 DATUM: NAD 83

CLIENT
RioTinto

PROJECT
DIAVIK DIAMOND MINES (2012) INC.

CONSULTANT
GOLDER

YYYY-MM-DD	2021-03-22
DESIGNED	ZY
PREPARED	LMS
REVIEWED	MC
APPROVED	RLS

TITLE
SPATIAL DISTRIBUTION OF TOTAL PHOSPHORUS DEPOSITION AROUND THE MINE

PROJECT NO.	PHASE	REV.	FIGURE
20136424	10000	0	F-3

PATH: I:\CLIENTS\DIAVIK\20136424\Mapping\Products\Fish\AEMP_2020\FigF-3_2020_AEMP_TP_Deposition_Rev0.mxd PRINTED ON: 2021-03-22 AT: 9:58:46 AM

Summary and Discussion

The key findings from the 2020 assessment are as follows:

- The background TP deposition rate estimated as the geometric mean of the deposition rates from the three control stations in 2020 was 0.056 mg/dm^2/yr, which was comparable to the background TP deposition rates estimated for 2017 to 2019 in the re-evaluation report.
- The TP zone of influence was estimated to be approximately 5.0 km from Mine centroid which is comparable to the dust zone of influence (i.e., 4.8 km) for 2017 to 2019 in the re-evaluation report.
- The anthropogenic TP loads for Lac de Gras and the watershed (excluding the Mine and lake) were 0.69 and 0.35 t/yr, respectively, for a total (including Mine effluent) of 1.3 t in 2020. The anthropogenic TP loads to Lac de Gras (direct and indirect) was consistent with those of 2017 to 2019 in the re-evaluation report.
- The contribution of anthropogenic sources to the total TP load to Lac de Gras was 5.4% (the rest was contributed from natural TP loads), which was comparable to the contribution (6.0%) estimated for 2017 to 2019 in the re-evaluation report.

The dust sampling program was not designed to be as precise as the AEMP effluent monitoring for measuring TP loads to Lac de Gras. The estimate of TP load from dust is considered to have low precision, with an order of magnitude uncertainty. Therefore, low confidence should be placed in the estimate of the TP load from dust and it should not be directly compared to the TP load from effluent, which is based on direct measurements of effluent volume and TP concentrations. The effect on lake water quality and biological effects of nutrient inputs from all Mine-related sources are being monitored directly by the AEMP.

References

ERM (ERM Consultants Canada). 2021. Diavik Diamond Mine: 2020 Dust Deposition Report. Prepared for Diavik Diamond Mines (2012) Inc. Vancouver, BC, Canada. February 2021.

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ATTACHMENT G

EUTROPHICATION INDICATORS RAW DATA

These data are provided electronically as an Excel file.

APPENDIX XIV

TRADITIONAL KNOWLEDGE STUDY

No information was available for this appendix in 2020 as traditional knowledge studies did not take place. The next traditional knowledge study is scheduled for 2021.

APPENDIX XV

WEIGHT-OF-EVIDENCE REPORT

No information was available for this appendix in 2020; the weight-of-evidence evaluation is only completed during comprehensive years.